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Bulletin 115

DEPARTMENT OF THE INTERIOR
FRANKLIN K. LANE, SECRETARY
BUREAU OF MINES
VAN. H. MANNING, DIRECTOR

COAL-MINE FATALITIES IN THE UNITED STATES 1870–1914

WITH

STATISTICS OF COAL PRODUCTION, LABOR, AND MINING METHODS, BY STATES AND CALENDAR YEARS

COMPILED BY
ALBERT H. FAY

WASHINGTON
GOVERNMENT PRINTING OFFICE
1916

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Bulletin 115

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tained from one source, as in so doing the statistics relating to employees would be on the same basis for all the States. The bureau has, therefore, used the number of employees as reported by the United States Geological Survey since 1889 (except 1909 and 1911). As the figures have been collected by one bureau, they are on a uniform basis and, furthermore, they are for calendar years and do not include coke-oven employees. For comparative purposes the number thus reported employed will be much better than one based on reports from 25 or 30 sources and for varying fiscal years.

The number of employees in the coal-mining industry for the year 1909 was compiled by the mining division of the Bureau of the Census and was published by the United States Geological Survey in 1910, as 666,552. In 1912 State figures for 1909 were compiled by the same bureau and published by the Bureau of Mines in Technical Paper 48,[a] in Bulletin 69,[b] and in each of the monthly statements of coal-mine fatalities to date. These publications have had wide circulation and have been used by many mining companies, State officials, and insurance organizations, and for this reason the figures showing coal-mine employees in 1909 as previously published by the bureau have been used in this bulletin.

The final census figures for 1909, published in 1913, show the number of employees on December 15, 1909, as 743,293. That figure, however, includes a certain number of coking establishments and, furthermore, as the coal-mining industry employs the largest number of men at that season of the year, the number reported on that date is too high to represent a fair average.

The census report for 1909, page 196, also gives the number of employees on the 15th day of each month during the year, the average of which is 681,090. The same report also gives the number of men employed on the 15th of each month during the year by States, the average of which is 680,872, as compared with 666,552, published by the United States Geological Survey and the Bureau of Mines. These two census figures, although agreeing closely, seemingly include certain coke workers. Taking everything into consideration, it is believed that the Bureau of Mines is justified in adhering to its first published figures (666,552), although this fails to check with the final census figures by about 2 per cent.

For the year 1911 the bureau collected accident statistics and at the same time obtained direct from the operators the number of men employed, both on surface and underground. The number of employees thus obtained has been used throughout this bulletin.

UNDERGROUND AND SURFACE EMPLOYEES.

Complete statistics showing separately the total underground employees, as well as surface employees at coal mines are not avail-

[a] Horton, F. W., Coal-mine accidents in the United States, 1896–1912, with monthly statistics for 1912, 1913, 74 pp.

[b] Horton, F. W., Coal-mine accidents in the United States and in foreign countries, 1913, 102 pp.

able. The number employed since 1889, as reported by the Geological Survey, is combined as one item, but coke-oven employees are not included. As there are no separate data for these two classes of employees, Table 6 has been prepared, the underground and surface employees being calculated on the basis of the 1911 returns to the Bureau of Mines. In this year 122,513 surface employees were reported at coal mines (exclusive of coke workers) or 16.82 per cent of the total. The total number employed each year since 1895 has been separated on the above basis, with underground and surface fatality rates calculated independently. The 20-year period chosen is considered sufficiently long to be thoroughly representative and thus to throw a little more light on the real underground hazard. For example, the fatality rate in 1913, based on all employees, was 3.725 per 1,000, whereas the underground rate was 4.218, or 13 per cent higher than the combined rate. The surface rate for the same year was 1.283. Similar comparisons with other years may be made.

COAL-MINE FATALITIES IN THE UNITED STATES, 1839–1914.

Table 1 shows by calendar years the total number of fatalities recorded for the coal-mining industry of the United States as compiled from the State mine inspectors' reports, and from other authentic sources. This table shows that since 1839 to the end of 1914, 53,078 men have been killed in and about the coal mines in the United States. This number, however, is not complete, as mining was carried on in all of the coal-mining States several years prior to inspection service, and as the number of fatalities that occurred in the early period of the industry has not been recorded, except for a few of the larger disasters in which 5 or more men were killed.

The 49,733 fatalities given in Table 2 represent those occurring in 89.46 per cent of the industry as based on the tonnage from 1807 to the end of 1913. The fatality rate per million tons mined during the 10 years from 1870 to 1879 was 8.70. If this figure be taken as representative of the early stages of the industry and applied to the remaining 10.54 per cent of the production from 1807 to and including 1909, not represented by accident statistics, an estimated 9,000 fatalities should be added to the 49,733, making the total to the end of 1913 as 58,733. The total fatalities to the end of 1914 are, therefore, 61,187, of which number 53,078 are accounted for in Table 1.

The total number of fatalities shown in Table 1 does not necessarily agree with the totals shown in Tables 2, 3, and 4, because in the latter tables only those fatalities have been included for which the corresponding number of men employed was obtainable. In Table 1 the figures covering 1888 to the end of 1914 do check with the above tables. Prior to 1888 the table covers a number of mine disasters in States in which the number of men employed was not obtainable. In the subsequent discussion of mine accidents Table 1 is ignored and the lessons to be drawn are based on Tables 2, 3, and 4, which contain complete comparable data for 49,733 fatalities.

TABLE 1.—COAL-MINE FATALITIES IN THE UNITED STATES, BY STATES AND YEARS, 1839 TO 1914.[a]

Year.	Alabama.	Arkansas.	California.	Colorado.	Georgia and North Carolina.	Illinois.	Indiana.	Iowa.	Kansas.	Kentucky.	Maryland.	Michigan.	Missouri.	Montana.	New Mexico.	North Dakota.	Ohio.	Oklahoma.	Oregon.	Pennsylvania (anthracite).	Pennsylvania (bituminous).	Tennessee.	Texas.	Utah.	Virginia.	Washington.	West Virginia.	Wyoming.	Total.
1839	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	40	.....	.....	.....	40
1847	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	.....	.....	.....	.....	.....	.....	.....	.....	7
1854	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19	.....	.....	.....	19
1855	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	55	.....	.....	.....	55
1869	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	179	.....	.....	.....	.....	.....	.....	.....	.....	179
1870	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	211	.....	.....	.....	.....	.....	.....	.....	.....	211
1871	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	210	.....	.....	.....	.....	.....	.....	.....	.....	210
1872	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	223	.....	.....	.....	.....	.....	.....	.....	.....	223
1873	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	263	.....	.....	.....	.....	.....	.....	.....	.....	263
1874	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	29	.....	.....	231	.....	.....	.....	.....	.....	.....	.....	.....	260
1875	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	24	.....	.....	236	.....	.....	.....	.....	.....	.....	.....	.....	260
1876	.....	.....	6	.....	.....	.....	.....	.....	.....	.....	0	.....	.....	.....	.....	.....	15	.....	.....	227	.....	.....	.....	.....	8	.....	.....	.....	256
1877	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	31	.....	.....	194	[b] 14	.....	.....	.....	.....	.....	.....	.....	244
1878	.....	.....	.....	.....	.....	.....	8	.....	.....	.....	(c)	.....	.....	.....	.....	.....	17	.....	.....	187	48	.....	.....	.....	.....	.....	.....	.....	235
1879	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....	.....	.....	.....	.....	2	.....	.....	262	55	.....	.....	.....	.....	.....	.....	.....	317
1880	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	3	.....	.....	.....	.....	.....	23	.....	.....	202	49	.....	.....	.....	.....	.....	.....	.....	280
1881	.....	.....	.....	.....	.....	.....	10	.....	.....	.....	8	.....	.....	.....	.....	.....	30	.....	.....	273	57	.....	.....	.....	.....	.....	.....	38	416
1882	.....	.....	.....	.....	.....	[d] 40	(c)	[e] 22	.....	.....	(c)	.....	.....	.....	.....	.....	25	.....	.....	291	92	.....	.....	.....	32	.....	.....	.....	502
1883	.....	.....	.....	6	.....	[d] 134	11	15	.....	.....	8	.....	.....	.....	.....	.....	22	.....	.....	323	54	.....	.....	.....	.....	.....	20	.....	593
1884	.....	.....	.....	64	.....	[f] 64	9	22	3	5	(c)	.....	.....	.....	.....	.....	32	.....	.....	332	119	.....	.....	.....	112	.....	(c)	.....	769
1885	.....	.....	.....	9	.....	50	7	16	9	1	(c)	.....	.....	.....	.....	.....	29	.....	.....	359	68	.....	.....	.....	.....	3	23	.....	574
1886	.....	.....	.....	6	.....	36	7	22	.....	1	.....	.....	.....	.....	.....	.....	42	.....	.....	278	74	.....	.....	.....	.....	4	47	15	519
1887	.....	.....	.....	12	.....	51	(c)	22	6	8	13	.....	.....	.....	.....	.....	30	.....	.....	314	84	.....	.....	.....	.....	2	11	.....	535
1888	.....	.....	.....	29	.....	57	17	30	40	14	(c)	.....	27	.....	.....	.....	32	.....	.....	364	90	.....	.....	.....	.....	(c)	28	.....	728
1889	.....	.....	.....	24	.....	41	(c)	22	12	12	5	.....	10	0	.....	.....	34	.....	.....	385	103	.....	.....	.....	.....	6	14	.....	668
1890	.....	.....	.....	16	.....	57	5	12	8	10	8	.....	18	1	.....	.....	39	.....	.....	378	145	.....	.....	.....	.....	7	29	.....	723
1891	.....	.....	.....	30	.....	49	5	27	11	16	6	.....	20	7	.....	.....	38	.....	.....	428	236	22	.....	.....	.....	14	47	.....	956
1892	.....	.....	.....	33	.....	69	19	21	(c)	8	6	.....	22	3	.....	.....	43	100	.....	418	134	13	.....	2	.....	55	45	.....	991
1893	17	.....	.....	46	.....	83	22	24	14	12	5	.....	18	1	4	.....	36	6	.....	455	131	13	.....	0	.....	9	62	.....	955
1894	21	.....	.....	19	.....	57	(c)	24	24	10	7	.....	19	6	11	.....	39	9	.....	445	123	14	.....	1	.....	50	79	.....	955
1895	39	.....	.....	23	39	78	23	23	11	13	9	.....	13	8	28	.....	51	9	.....	421	153	37	.....	1	.....	39	64	60	1,142
1896	25	.....	.....	68	.....	70	28	18	12	6	6	.....	8	(c)	9	.....	42	15	.....	501	178	22	.....	2	.....	8	65	.....	1,083
1897	39	17	.....	36	.....	73	16	23	6	12	5	.....	12	11	5	.....	39	28	.....	423	149	10	.....	2	.....	7	77	.....	990
1898	45	5	.....	23	.....	90	21	22	17	6	4	.....	10	7	8	.....	48	23	.....	411	199	19	.....	3	.....	11	90	.....	1,062
1899	40	(c)	.....	40	23	73	16	25	16	7	5	4	11	(c)	18	.....	56	28	.....	461	258	20	.....	0	.....	45	95	.....	1,241
1900	37	(c)	.....	31	.....	102	19	29	21	17	7	10	19	7	9	.....	71	35	.....	411	264	10	.....	209	.....	31	150	.....	1,459
1901	40	18	.....	55	.....	107	24	29	11	21	12	6	16	7	15	.....	64	57	.....	513	301	43	.....	8	17	27	133	50	1,574
1902	50	13	.....	73	.....	107	24	49	28	19	11	8	10	12	14	.....	86	42	.....	300	455	226	.....	8	.....	34	134	21	1,734

1903	57	*11*	....	44	....	158	52	27	33	27	12	8	17	5	22	....	124	42	....	518	395	26	....	7	....	25	147	*169*	1,926
1904	83	(c)	....	94	....	173	34	25	31	20	10	6	11	9	8	....	117	29	....	595	533	28	....	9	....	31	149	(c)	1,995
1905	187	8	....	65	....	203	46	37	41	31	15	9	11	8	7	....	126	41	....	644	475	29	....	7	....	12	212	*18*	2,233
1906	96	13	....	89	....	161	31	29	39	39	6	5	16	13	23	....	131	44	....	557	476	32	....	4	*56*	22	277	(c)	2,138
1907	154	13	....	107	....	192	53	40	37	32	*3*	7	8	13	34	....	154	39	....	708	799	30	....	5	*11*	37	736	*30*	3,242
1908	108	14	....	63	....	172	45	31	38	40	*6*	6	10	21	24	4	113	46	....	678	571	34	....	5	....	25	310	81	2,445
1909	129	15	*6*	97	2	458	49	39	32	34	20	9	21	11	14	0	110	48	1	567	500	29	4	15	27	39	336	30	2,642
1910	238	14	0	323	0	143	51	33	17	86	18	6	14	12	16	2	159	39	0	601	521	38	7	18	57	43	329	36	2,821
1911	209	12	0	88	0	172	46	38	42	44	15	7	8	14	11	1	107	27	1	699	515	111	8	13	68	27	341	32	2,656
1912	123	6	2	96	2	163	35	19	30	51	15	8	19	7	16	0	135	99	1	601	446	18	2	19	75	14	381	36	2,419
1913	124	12	2	108	3	164	66	26	28	48	13	3	10	20	272	6	165	23	0	618	609	35	4	17	24	22	337	26	2,785
1914	128	11	0	75	1	193	44	37	33	61	18	2	19	8	18	3	64	31	1	595	402	26	11	22	27	17	556	51	2,454
Total	1,989	182	16	1,892	70	3,840	843	881	650	711	294	104	397	211	586	16	2,574	860	4	18,497	9,875	885	86	377	607	668	5,324	691	53,078

a Figures in italics represent incomplete fatality records.
b Last three months of year only.
c Reports either not published or not available.
d Fiscal year ending June 30.
e Includes 1881.
f Includes last six months of 1883.

TABLE 2.—PRODUCTION, EMPLOYEES, AND FATALITIES, SHOWING PERCENTAGE OF COAL-MINING INDUSTRY FOR WHICH COMPLETE RETURNS ARE AVAILABLE, 1870 TO 1914.

[See figs. 1 and 2.]

Year.	Total United States.			Portion of United States under inspection service or reporting accidents.									
				Total for States reporting accidents.				Number killed.			Production per death, short tons.[d]	Days worked	Average tonnage per man.[d]
				Production.		Employees.							
	Production, short tons.[a]	Value per ton at mine.[a]	Number employed.[a]	Short tons.	Per cent of total.	Number employed.[c]	Per cent of total.	Total.[b]	Per 1,000 employed.	Per 1,000,000 short tons mined.			Per year. / Per day.
1807–1869	410,395,133												
1870	33,035,580			15,664,275	47.42	35,600		211	5.93	13.47	74,238		440
1871	46,885,080			19,342,057	41.25	37,488		210	5.60	10.86	92,105		516
1872	51,453,399			24,233,166	47.10	44,745		223	4.98	9.20	108,669		542
1873	57,602,480			26,152,837	45.40	48,199		263	5.46	10.06	99,440		543
1874	52,605,920			28,086,375	53.39	67,152		260	3.87	9.26	108,025		418
1875	52,348,320			27,350,025	52.25	85,005		260	3.06	9.51	105,192		322
1876	53,280,000			26,293,245	49.35	85,474		242	2.83	9.20	108,650		308
1877	60,501,760			30,910,316	51.09	81,142		225	2.77	7.28	137,379		381
1878	57,935,600			36,809,682	63.54	89,751		235	2.62	6.38	156,637		410
1879	68,105,799			46,447,793	68.20	96,133		317	3.30	6.82	146,523		483
1880	71,481,570			53,083,570	74.26	123,736		274	2.21	5.16	193,736		429
1881	85,881,030			56,304,138	65.56	116,128		340	2.93	6.04	165,600		485
1882	103,551,189			78,326,909	75.64	162,883		448	2.75	5.72	174,837		481
1883	115,707,525			82,356,134	71.18	162,248		542	3.34	6.58	151,949		508
1884	120,155,551			87,264,984	72.63	192,369		538	2.80	6.17	162,208		454
1885	111,160,295			92,922,981	83.59	213,178		549	2.58	5.91	169,259		436
1886	113,680,427			94,538,058	83.16	219,699		494	2.25	5.23	191,373		430
1887	130,650,511			103,774,783	79.43	228,777		504	2.20	4.86	205,902		454
1888	148,659,657			129,763,086	87.29	285,517		728	2.55	5.61	178,246		454
1889	141,279,513	$1.13	311,717	127,875,451	90.54	283,198	90.85	668	2.36	5.22	191,430		452
1890	157,770,963	1.12	318,204	146,192,491	92.66	291,217	91.52	723	2.52	5.01	199,444	216	503 / 2.33
1891	168,566,669	1.13	332,147	157,654,975	93.53	310,683	93.54	956	3.08	6.06	164,912	215	507 / 2.36
1892	179,329,071	1 16	341,943	165,708,630	92.40	317,140	92.75	991	3.12	5.98	167,214	212	523 / 2.47
1893	182,352,774	1.14	363,309	177,616,520	97.40	355,091	97.74	958	2.70	5.39	185,403	201	500 / 2.49
1894	170,741,526	1.09	376,204	162,139,619	94.96	358,642	95.33	958	2.67	5.91	169,248	178	452 / 2.54
1895	193,117,530	1.02	382,579	190,104,270	98.44	376,024	98.21	1,142	3.04	6.00	166,466	195	505 / 2.59
1896	191,986,357	1.02	393,342	185,122,828	96.43	380,477	96.73	1,083	2.85	5.85	170,935	185	487 / 2.63
1897	200,229,199	.99	397,701	194,731,837	97.25	388,585	97.71	990	2.55	5.08	196,699	179	501 / 2.80
1898	219,976,267	.95	401,221	213,734,037	97.16	391,841	97.66	1,062	2.71	4.97	201,256	190	545 / 2.87
1899	253,741,192	1.01	410,635	243,993,172	96.16	395,607	96.34	1,241	3.14	5.08	196,610	214	617 / 2.88

1870	260,694,027	1.14	445,551	260,164,397	96.47	432,448	96.40	1,489	3.44	5.72	174,724	212	602	2.84
1871	293,290,816	1.19	485,544	292,449,047	96.37	490,807	96.02	1,674	3.27	5.40	186,145	216	606	2.81
1872	301,590,439	1.23	518,197	299,687,066	98.37	510,217	98.46	1,724	3.38	5.81	172,092	197	581	2.95
1873	357,356,416	1.41	566,260	353,004,631	98.52	556,551	98.29	1,926	3.46	5.47	182,796	220	633	2.98
1874	351,816,898	1.26	563,668	339,164,812	96.40	573,573	96.58	1,996	3.46	5.68	170,007	202	592	2.98
1875	392,722,635	1.21	626,045	386,379,243	98.38	615,368	98.29	2,232	3.63	5.78	178,109	212	628	2.96
1876	414,157,278	1.24	640,780	405,955,888	98.02	630,288	98.36	2,138	3.39	5.27	196,676	209	644	3.08
1877	480,263,424	1.28	680,492	477,892,536	99.49	674,613	99.14	3,242	4.81	6.78	147,407	231	706	3.06
1878	415,842,668	1.28	660,458	409,309,587	98.43	676,573	98.33	2,445	3.60	5.97	167,407	195	603	3.09
1879	460,814,616	1.20	a 666,532	460,307,263	99.89	666,535	99.99	2,642	3.96	5.73	174,416	.....	661	.....
1880	501,566,378	1.25	725,080	501,566,378	100.00	725,080	100.00	2,821	3.89	5.62	177,808	220	662	3.15
1881	496,371,126	1.26	f 728,348	496,371,126	100.00	728,348	100.00	2,656	3.65	5.35	186,887	220	682	3.10
1882	534,466,580	1.30	723,662	534,466,580	100.00	722,662	100.00	2,419	3.35	4.53	220,945	225	740	3.29
1883	570,048,125	1.33	747,644	570,048,125	100.00	747,644	100.00	2,785	3.73	4.89	204,685	238	762	3.20
Total	9,844,947,843	.....	.....	8,806,855,193	89.46	14,966,511	.....	49,723	3.32	5.65	177,063	.....	643	.....
1914	513,625,477	1.33	763,185	513,625,477	100.00	763,185	100.00	2,454	3.22	4.78	209,261	207	673	3.25

a Mineral Resources, U. S. Geol. Survey.
b Summation based on State mine inspectors' reports. (See Table 3.)
c Number employed 1870–1888 selected from State mine inspectors' reports; 1889–1914 (except 1909 and 1911), selected from Mineral Resources, U. S. Geol. Survey.
d Calculated on basis of production represented by inspection States.
e Bureau of Census.
f Bureau of Mines.

TABLE 2A.—NUMBER OF MEN EMPLOYED IN AND ABOUT THE COAL MINES IN THE UNITED STATES, BY STATES; 1889–1914.[a]

State.	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901
Alabama	6,864	10,642	9,302	10,675	11,294	10,859	10,346	9,894	10,597	10,733	13,481	13,967	17,370
Arkansas	677	938	1,317	1,128	1,559	1,493	1,218	1,507	1,990	2,555	2,313	2,900	3,144
California	253	364	256	187	158	125	190	177	381	294	363	378	428
Colorado	4,904	5,827	6,000	5,747	7,202	6,507	6,125	6,704	5,852	6,440	7,166	7,459	8,870
Georgia	733	425	850	467	736	729	848	713	469	534	567	681	791
Idaho	.....	[b] 80	[b] 80	[b] 90	[b] 70	[b] 95	[b] 61	[b] 18	[b] 58	[c] 37	[d] 76	.....	.....
Illinois	30,076	28,574	32,951	34,585	35,390	38,477	38,630	39,560	33,788	35,026	36,756	39,101	41,880
Indiana	6,448	5,489	5,879	6,436	7,644	8,603	8,530	8,806	8,886	8,971	9,712	11,720	12,968
Iowa	9,247	8,130	8,124	8,170	8,863	9,995	10,066	9,672	10,703	10,262	10,971	11,608	12,653
Kansas	5,956	4,523	6,201	6,559	7,310	7,339	7,482	7,127	6,639	7,197	8,000	8,459	9,928
Kentucky	5,144	5,259	6,355	6,724	6,581	8,083	7,865	7,549	7,983	7,614	7,461	9,680	10,307
Maryland	3,702	3,842	3,891	3,886	3,935	3,974	3,912	4,039	4,719	4,818	4,624	5,319	5,333
Michigan	261	180	223	230	162	228	320	320	537	715	1,291	1,704	2,276
Missouri	6,631	5,971	6,199	5,893	7,375	7,573	6,299	5,982	6,414	6,542	7,136	8,180	9,871
Montana	848	1,251	1,119	1,158	1,401	1,782	2,184	2,335	2,337	2,359	2,378	2,376	2,158
New Mexico	1,015	827	806	1,083	1,011	985	1,383	1,569	1,659	1,873	1,750	2,037	2,478
North Dakota	75	.....	.....	54	88	77	65	141	170	151	210	326	280
Ohio	19,343	20,576	22,182	23,576	23,931	27,105	24,644	25,500	26,410	26,986	26,038	27,628	32,111
Oklahoma	1,862	2,571	2,891	3,257	3,446	3,101	3,212	3,549	3,168	3,216	4,084	4,525	6,706
Oregon	160	208	100	90	110	88	414	254	254	199	124	141	187
Pennsylvania (anthracite)	123,676	126,000	126,350	129,050	132,944	131,603	142,917	148,991	149,884	145,504	139,608	144,206	145,309
Pennsylvania (bituminous)	62,084	61,333	63,661	66,655	71,931	75,010	71,130	72,625	77,272	79,611	82,812	92,692	101,904
Tennessee	4,031	5,062	5,097	4,926	4,976	5,542	5,120	6,531	6,337	6,643	6,949	7,646	9,046
Texas	543	674	787	871	996	1,062	1,642	1,953	1,766	2,130	2,410	2,844	3,051
Utah	551	429	621	646	576	671	670	679	704	739	743	1,308	1,712
Virginia	1,523	1,295	820	836	961	1,635	2,158	2,510	2,344	1,855	1,960	3,631	4,152
Washington	2,657	2,206	2,447	2,564	2,757	2,662	2,840	2,622	2,739	3,145	3,330	3,670	4,545
West Virginia	9,778	12,236	14,227	14,867	16,524	17,824	19,159	19,078	20,504	21,607	23,625	29,163	30,935
Wyoming	2,675	3,272	3,411	3,133	3,378	3,032	3,449	2,987	3,137	3,475	4,697	5,332	5,151
Total	311,717	318,204	332,147	341,943	363,399	376,204	382,879	393,342	397,701	401,221	410,635	448,581	485,544

State.	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914
Alabama	16,439	21,438	17,811	19,595	20,555	21,388	19,197	17,760	22,230	22,003	22,613	24,552	24,042
Arkansas	3,595	4,157	4,580	4,192	4,298	5,085	5,337	5,206	5,568	5,338	4,536	4,652	4,339
California	207	203	168	135	41	32	34	15	14	45	52	35	36
Colorado	8,956	9,229	8,123	11,020	11,368	14,223	14,523	11,472	15,864	14,373	13,000	11,990	10,098
Georgia	755	681	881	801	737	808	670	460	396	510	450	500	355
Idaho	*d* 70	*d* 86	*e* 57	*f* 61	*c* 40	*g* 66	*c* 39	17	*c* 19	*c* 24	*h* 20	*i* 17	*k* 54
Illinois	47,411	50,596	54,685	58,053	61,988	65,581	68,035	69,425	72,645	75,656	78,098	79,529	79,499
Indiana	15,457	17,017	19,587	25,323	20,970	21,022	18,380	20,937	21,878	20,991	21,651	22,235	23,175
Iowa	12,434	14,162	15,629	15,113	15,260	15,585	16,021	17,286	16,666	16,852	16,370	15,757	16,057
Kansas	9,461	10,924	12,198	11,926	14,355	12,439	13,916	12,359	14,870	11,823	11,646	12,479	12,448
Kentucky	13,727	14,354	14,235	14,685	15,272	16,971	16,996	16,903	20,316	24,124	24,304	26,332	28,764
Maryland	5,827	5,859	5,671	5,948	6,438	5,880	6,079	8,004	5,809	6,079	6,162	5,645	5,403
Michigan	2,344	2,768	3,549	3,696	3,971	3,962	4,247	3,496	3,575	3,248	3,113	3,305	2,800
Missouri	9,739	9,544	10,137	8,962	9,557	8,448	8,988	9,188	9,691	9,607	9,704	10,418	9,549
Montana	1,938	2,155	2,506	2,181	2,394	2,735	3,146	4,535	3,837	3,864	3,440	3,630	3,350
New Mexico	1,849	1,789	1,849	2,108	2,070	2,970	3,448	3,317	3,585	3,700	3,928	4,329	4,178
North Dakota	402	486	554	626	488	562	631	972	534	760	622	641	558
Ohio	38,965	41,936	42,634	43,399	45,438	46,833	47,407	38,114	46,641	45,459	45,527	45,815	45,401
Oklahoma	5,574	7,704	8,487	7,712	8,251	8,398	8,651	8,689	8,657	8,729	8,785	9,044	8,078
Oregon	265	235	334	316	209	184	214	235	153	304	222	203	190
Pennsylvania (anthracite)	148,141	150,483	155,861	165,406	162,355	167,234	174,174	166,801	169,497	173,940	174,030	175,745	179,679
Pennsylvania (bituminous)	112,630	129,265	135,100	143,629	152,099	163,295	165,961	159,321	175,403	171,108	165,144	172,196	184,201
Tennessee	8,750	9,961	10,416	11,928	11,452	12,052	11,812	10,031	11,930	11,124	10,309	11,263	10,116
Texas	2,369	2,380	2,921	3,008	3,048	4,227	4,400	4,196	4,197	4,980	5,127	5,101	4,635
Utah	1,826	1,925	1,874	1,361	1,572	2,203	2,664	3,014	3,053	3,446	3,328	4,158	4,112
Virginia	3,912	5,608	5,165	5,730	5,131	6,670	6,208	6,191	7,264	8,107	8,678	9,162	9,183
Washington	4,404	4,768	5,287	4,765	4,529	5,945	5,484	5,992	6,314	7,236	5,519	5,794	5,805
West Virginia	35,500	41,554	47,235	48,389	50,960	59,029	56,861	55,433	68,663	66,800	68,248	74,786	78,963
Wyoming	5,250	4,993	5,660	5,977	5,934	6,645	6,915	7,123	7,771	8,118	8,036	8,331	8,117
Total	**518,197**	**566,260**	**593,693**	**636,045**	**640,799**	**696,492**	**696,428**	**696,552**	**725,030**	**722,348**	**722,062**	**747,644**	**763,185**

a Compiled from "Mineral Resources of the United States," U. S. Geol. Survey, except 1909, from Bureau of Census, and 1911, from Bureau of Mines.
b Includes North Carolina.
c Includes Alaska.
d Includes Alaska and North Carolina.
e Includes Nevada and North Carolina.
f Includes Alaska, Nevada, and North Carolina
g Includes Alaska, Nevada, and Nebraska.
h Includes Nevada.
i Includes Alaska and Nevada.
k Includes Nevada and South Dakota.

TABLE 3.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEARS 1870–1914, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE. (FOR STATES HAVING COMPLETE INSPECTION RECORDS.[a])

Year.	Killed underground.												Killed in shaft.					Killed on surface.							Grand total.	(For States making up total for each year, see table indicated below).
	Falls of roof (coal, rock, etc.)	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).[b]	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.		
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22			Table No.
1870	12	45	15	10	.....	8	1	....	1	....	....	71	163	4	....	23	....	27	1	....	8	5	4	3	21	211	125
1871	18	44	28	31	.....	16	4	....	1	....	20	20	122	5	....	....	1	6	4	....	12	1	....	5	22	210	125
1872	48	49	24	29	.....	16	2	....	....	....	....	11	179	13	2	5	....	20	9	....	8	....	....	7	24	223	125
1873	47	64	36	32	.....	16	....	....	3	....	....	16	214	12	1	2	....	16	14	....	8	....	3	8	33	263	125
1874	60	42	37	28	.....	16	4	....	5	....	....	24	216	8	3	7	1	19	8	....	5	7	....	5	25	260	8
1875	61	28	28	17	.....	33	1	....	....	....	....	33	201	15	4	7	....	26	6	....	14	3	3	7	33	260	8
1876	54	43	36	27	.....	35	2	....	1	....	....	14	212	9	....	6	....	15	5	....	5	1	1	3	15	242	8
1877	73	64	27	16	.....	13	1	....	1	....	....	8	203	4	....	4	....	8	5	....	3	....	1	5	14	223	8
1878	75	42	30	22	.....	18	4	....	2	....	....	11	204	1	1	....	....	2	6	....	7	8	1	7	23	225	9
1879	112	58	47	33	.....	17	....	....	1	....	....	16	284	5	1	1	....	7	10	....	7	....	4	5	26	317	9
1880	99	39	47	22	.....	15	4	....	3	....	....	18	247	6	....	1	....	7	7	....	8	....	1	4	20	274	9
1881	102	42	66	28	.....	19	3	....	6	....	....	29	295	6	....	1	2	9	12	....	14	3	2	5	36	340	9
1882	150	55	61	34	.....	28	1	....	2	....	3	35	369	14	8	6	....	28	15	....	15	1	8	12	51	448	9
1883	170	43	59	37	.....	40	2	....	6	....	....	110	467	15	3	7	....	25	18	....	12	4	6	10	50	542	10
1884	184	59	82	44	.....	43	5	....	1	....	7	40	465	14	3	7	....	24	3	....	11	6	10	19	49	538	10
1885	197	66	44	30	.....	47	11	....	2	....	....	60	457	17	7	14	....	38	15	....	13	9	10	7	54	549	11
1886	173	62	54	60	.....	38	11	....	3	....	....	20	421	13	5	6	....	24	11	....	11	6	5	16	48	494	11
1887	180	96	79	22	.....	28	10	....	5	....	1	17	438	18	3	6	1	28	10	....	11	1	5	11	38	504	12
1888	255	81	82	22	84	65	3	....	6	....	....	48	646	17	7	14	....	38	8	....	9	4	9	14	44	728	13
1889	265	87	90	33	.....	46	8	....	3	....	....	36	568	9	1	27	4	41	16	....	11	8	10	14	59	668	14
1890	262	78	84	76	.....	48	7	....	8	....	34	27	634	21	4	20	....	45	21	....	10	9	9	15	64	783	15
1891	345	94	98	158	5	72	13	....	4	....	5	54	845	18	4	15	....	37	16	....	14	7	10	24	71	956	16
1892	349	108	110	111	104	60	....	....	3	....	2	55	902	20	4	11	....	35	20	....	12	....	7	15	54	991	17
1893	412	106	118	53	22	62	....	....	6	....	14	35	828	27	6	17	2	52	15	....	16	4	11	22	68	948	18

| | | |

TABLE 4.—COAL-MINE FATALITIES IN THE UNITED STATES BY PRINCIPAL CAUSES, 1870-1914 (FOR INSPECTION STATES ONLY).

[See fig. 3.]

Year.	Falls of roof and pillar coal. (1 and 2)			Mine cars and locomotives. (3)			Gas and dust explosions. (4 and 5)			Explosives. (6)			Miscellaneous underground. (7 to 12)			Total shaft fatalities. (13 to 16)			Total surface fatalities. (17 to 22)			Grand total.		Number of men employed.[a]
	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	**Number killed.**	**Number killed per 1,000 employed.**	
1870	57	27.01	1.601	15	7.11	0.421	10	4.74	0.281	8	3.79	0.225	73	34.60	2.051	27	12.80	0.758	21	9.95	0.590	**211**	**5.927**	35,600
1871	62	29.52	1.654	28	13.33	.747	31	14.76	.827	16	7.62	.427	45	21.43	1.200	6	2.86	.160	22	10.48	.587	**210**	**5.602**	37,488
1872	97	43.50	2.168	24	10.76	.536	29	13.00	.648	16	7.18	.358	13	5.83	.291	20	8.97	.447	24	10.76	.536	**223**	**4.984**	44,745
1873	111	42.21	2.303	36	13.69	.747	32	12.17	.664	16	6.08	.332	19	7.22	.394	16	6.08	.332	33	12.55	.685	**263**	**5.457**	48,199
1874	102	39.23	1.519	37	14.23	.551	28	10.77	.417	16	6.15	.238	33	12.69	.492	19	7.31	.283	25	9.62	.372	**260**	**3.872**	67,152
1875	89	34.23	1.047	28	10.77	.329	17	6.54	.200	33	12.69	.388	34	13.08	.400	26	10.00	.306	33	12.69	.388	**260**	**3.058**	85,005
1876	97	40.08	1.135	36	14.88	.421	27	11.16	.316	35	14.46	.410	17	7.02	.199	15	6.20	.175	15	6.20	.175	**242**	**2.831**	85,474
1877	137	60.89	1.688	27	12.00	.333	16	7.11	.197	13	5.78	.160	10	4.44	.123	8	3.56	.099	14	6.22	.173	**225**	**2.773**	81,142
1878	117	49.79	1.304	30	12.77	.334	22	9.36	.245	18	7.66	.201	17	7.23	.189	2	0.85	.022	29	12.34	.323	**235**	**2.618**	89,751
1879	170	53.63	1.768	47	14.83	.489	33	10.41	.343	17	5.36	.177	17	5.36	.177	7	2.21	.073	26	8.20	.271	**317**	**3.298**	96,133
1880	138	50.37	1.115	47	17.15	.380	22	8.03	.178	15	5.47	.121	25	9.13	.202	7	2.55	.056	20	7.30	.162	**274**	**2.214**	123,736
1881	144	42.35	1.240	66	19.41	.568	28	8.23	.241	19	5.59	.164	38	11.18	.327	9	2.65	.078	36	10.59	.310	**340**	**2.928**	116,128
1882	205	45.76	1.258	61	13.62	.374	34	7.59	.209	28	6.25	.172	41	9.15	.252	28	6.25	.172	51	11.38	.313	**448**	**2.750**	162,883
1883	213	39.30	1.313	59	10.89	.364	37	6.83	.228	40	7.38	.247	118	21.77	.727	25	4.61	.154	50	9.22	.308	**542**	**3.341**	162,248
1884	243	45.17	1.263	82	15.24	.426	44	8.18	.229	43	7.99	.224	53	9.85	.275	24	4.46	.125	49	9.11	.255	**538**	**2.797**	192,369
1885	263	47.91	1.234	44	8.01	.206	30	5.46	.141	47	8.56	.220	73	13.30	.343	38	6.92	.178	54	9.84	.253	**549**	**2.575**	213,178
1886	235	47.57	1.070	54	10.93	.246	60	12.15	.273	38	7.69	.173	34	6.88	.155	24	4.86	.109	49	9.92	.223	**494**	**2.249**	219,699
1887	276	54.76	1.207	79	15.67	.345	22	4.36	.096	28	5.56	.123	33	6.55	.144	28	5.56	.122	38	7.54	.166	**504**	**2.203**	228,777
1888	336	46.16	1.177	82	11.26	.287	106	14.56	.371	65	8.93	.228	57	7.83	.200	38	5.22	.133	44	6.04	.154	**728**	**2.550**	285,517
1889	352	52.69	1.243	90	13.47	.318	33	4.94	.117	46	6.89	.162	47	7.04	.166	41	6.14	.145	59	8.83	.208	**668**	**2.359**	283,198
1890	340	46.38	1.168	84	11.46	.288	76	10.37	.261	48	6.55	.165	76	10.37	.261	45	6.14	.154	64	8.73	.220	**733**	**2.517**	291,217
1891	439	45.92	1.413	98	10.25	.315	163	17.05	.525	72	7.53	.232	76	7.95	.245	37	3.87	.119	71	7.43	.228	**956**	**3.077**	310,683
1892	457	46.12	1.441	110	11.10	.347	215	21.70	.678	60	6.05	.189	60	6.05	.189	35	3.53	.111	54	5.45	.170	**991**	**3.125**	317,140
1893	518	54.07	1.459	118	12.32	.332	85	8.87	.239	62	6.47	.175	55	5.74	.155	52	5.43	.146	68	7.10	.192	**958**	**2.698**	355,091
1894	474	49.48	1.322	109	11.38	.304	55	5.74	.153	86	8.98	.240	93	9.71	.259	58	6.05	.162	83	8.66	.231	**958**	**2.671**	358,642
1895	503	44.05	1.338	123	10.77	.327	225	19.70	.599	99	8.67	.263	64	5.60	.170	49	4.29	.130	79	6.92	.210	**1,142**	**3.037**	376,024
1896	583	53.83	1.532	119	10.99	.313	128	11.82	.336	72	6.65	.189	60	5.54	.158	41	3.78	.108	80	7.39	.210	**1,083**	**2.846**	380,477
1897	559	56.47	1.439	96	9.70	.247	82	8.28	.211	88	8.89	.227	63	6.36	.162	39	3.94	.100	63	6.36	.162	**990**	**2.548**	388,585
1898	601	56.59	1.534	132	12.43	.337	69	6.50	.176	75	7.06	.191	67	6.31	.171	41	3.86	.105	77	7.25	.196	**1,062**	**2.710**	391,841
1899	660	53.18	1.668	141	11.36	.357	131	10.56	.331	93	7.49	.235	82	6.61	.207	44	3.55	.111	90	7.25	.228	**1,241**	**3.137**	395,607

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TABLE 5.—COAL-MINE FATALITIES, BY STATES AND PRINCIPAL CAUSES, DURING PERIODS ENDING DEC. 31, 1913, FOR WHICH CONTINUOUS RECORDS ARE AVAILABLE.

[See Pls. I and II.]

State.	Period ending 1913.	Falls of roof and pillar coal. (1 and 2)			Mine cars and locomotives. (3)			Gas and dust explosions. (4 and 5)			Explosives. (6)			Miscellaneous underground. (7 to 12)			Total shaft fatalities. (13 to 16)			Total surface fatalities. (17 to 22)			Number killed.	
		Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Total.	Per 1,000 employed.
	Yrs.																							
Alabama	21	713	38.31	2.01	193	10.37	0.55	620	33.32	1.75	96	5.16	0.27	203	10.91	0.57	8	0.43	0.02	28	1.50	0.08	1,861	5.25
Arkansas	9	65	60.75	1.46	2	1.87	.05	2	1.87	.05	15	14.01	.34	20	18.69	.45	2	1.87	.05	1	.94	.02	107	2.42
Colorado	28	852	49.02	3.50	141	8.11	.58	517	29.75	2.12	60	3.45	.25	83	4.78	.34	36	2.07	.15	49	2.82	.20	1,738	7.14
Georgia	5	6	85.71	2.60	0	.....	.....	0	.....	.....	1	14.29	.43	0	.....	.....	0	.....	.....	0	.....	.....	7	3.03
Illinois	29	1,616	47.40	1.19	414	12.14	.30	170	4.99	.13	459	13.47	.34	350	10.27	.26	266	7.80	.20	134	3.93	.10	3,409	2.53
Indiana	19	305	45.07	.97	75	11.04	.24	57	8.39	.18	132	19.44	.42	22	3.24	.07	71	10.46	.23	16	2.36	.05	679	2.16
Iowa	26	426	59.00	1.31	76	10.53	.23	44	6.10	.13	74	10.25	.23	18	2.49	.06	65	9.00	.20	19	2.63	.06	722	2.22
Kansas	21	259	49.05	1.20	12	2.27	.06	33	6.25	.15	131	24.81	.61	26	4.93	.12	50	9.47	.23	17	3.22	.08	528	2.45
Kentucky	26	316	49.76	.98	46	7.25	.14	74	11.65	.23	89	14.02	.28	39	6.14	.12	24	3.78	.08	47	7.40	.15	635	1.98
Maryland	23	127	57.73	1.08	30	13.64	.25	0	.....	.....	5	2.27	.04	36	16.36	.31	0	.....	.....	22	10.00	.19	220	1.87
Michigan	14	51	52.04	1.13	2	2.04	.04	0	.....	.....	15	15.31	.33	15	15.31	.33	10	10.20	.22	5	5.10	.11	98	2.16
Missouri	26	235	62.17	1.10	19	5.03	.09	40	10.58	.19	43	11.38	.20	10	2.64	.05	27	7.14	.13	4	1.06	.02	378	1.78
Montana	14	88	55.34	2.15	23	14.47	.56	0	.....	.....	11	6.92	.27	27	16.98	.66	1	.63	.03	9	5.66	.22	159	3.89
New Mexico	21	160	28.17	3.22	43	7.57	.87	321	56.51	6.46	24	4.23	.48	16	2.82	.32	0	.....	.....	4	.70	.08	568	11.43
North Dakota	6	6	46.16	1.44	2	15.38	.48	0	.....	.....	3	23.08	.72	2	15.38	.48	0	.....	.....	0	.....	.....	13	3.12
Ohio	30	1,509	65.84	1.57	277	12.08	.29	64	2.79	.07	161	7.02	.17	115	5.02	.12	79	3.45	.08	87	3.80	.09	2,292	2.39
Oklahoma	21	153	20.99	1.14	78	10.70	.58	262	35.94	1.96	115	15.77	.86	79	10.84	.59	25	3.43	.19	17	2.33	.13	729	5.45
Oregon	5	1	33.33	.90	0	.....	.....	2	66.67	1.79	0	.....	.....	0	.....	.....	0	.....	.....	0	.....	.....	3	2.69
Pennsylvania (anthracite)	44	7,378	41.65	1.42	2,403	13.56	.46	1,344	7.59	.26	1,790	10.10	.35	1,637	9.24	.32	843	4.76	.16	2,321	13.10	.45	17,716	3.42
Pennsylvania (bituminous)	36	5,393	56.93	1.64	1,452	15.33	.44	1,309	13.82	.40	185	1.95	.05	512	5.40	.16	217	2.29	.06	405	4.28	.12	9,473	2.87
Tennessee	23	361	42.03	1.81	49	5.70	.25	339	39.47	1.70	49	5.70	.25	27	3.14	.13	1	.12	.....	33	3.84	.16	859	4.30
Texas	5	16	64.00	.67	2	8.00	.08	0	.....	.....	2	8.00	.09	3	12.00	.13	1	4.00	.04	1	4.00	.04	25	1.08
Utah	22	95	26.76	2.48	25	7.04	.65	205	57.75	5.34	5	1.40	.13	7	1.97	.18	3	.84	.08	15	4.23	.39	355	9.25
Virginia	5	131	52.19	3.33	32	12.75	.81	25	9.96	.63	10	3.98	.25	34	13.55	.86	1	.40	.03	18	7.17	.46	251	6.37
Washington	25	182	28.44	1.75	81	12.65	.78	195	30.47	1.87	32	5.00	.30	102	15.94	.98	13	2.03	.12	35	5.47	.33	640	6.14
West Virginia	29	2,452	51.64	2.57	557	11.73	.58	1,036	21.82	1.09	155	3.27	.16	202	4.25	.21	67	1.41	.07	279	5.88	.29	4,748	4.97
Wyoming	6	114	47.30	2.46	22	9.13	.48	67	27.80	1.45	13	5.40	.28	17	7.05	.37	1	.41	.02	7	2.91	.15	241	5.21
Total	.....	23,011	47.49	1.57	6,056	12.50	.42	6,726	13.88	.46	3,675	7.59	.25	3,602	7.43	.25	1,811	3.74	.12	3,573	7.37	.24	48,454	3.21

TABLE 6.—FATALITY RATES IN AND ABOUT THE COAL MINES IN THE UNITED STATES BASED ON UNDERGROUND AND SURFACE EMPLOYEES.[a]

Year.	Number employed.			Number killed.																	
				Underground.														Surface. (17 to 22)		Total.	
				Falls of roof and pillar coal. (1 and 2)		Mine cars and locomotives. (3)		Gas and dust explosions. (4 and 5)		Explosives. (6)		Miscellaneous underground. (7 to 12)		Shaft. (13 to 16)		Underground (total).					
	Underground.[a]	Surface.[a]	Total.[b]	Number killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.
1895	312,777	63,247	376,024	503	1.608	123	0.393	225	0.719	99	0.317	64	0.205	49	0.157	1,063	3.399	79	1.249	1,142	3.037
1896	316,481	63,996	380,477	583	1.842	119	.376	128	.404	72	.227	60	.190	41	.130	1,003	3.169	80	1.250	1,083	2.846
1897	323,225	65,360	388,585	560	1.729	96	.297	82	.254	88	.272	63	.195	30	.121	927	2.868	63	.964	990	2.548
1898	325,933	65,908	391,841	601	1.844	132	.405	69	.212	75	.230	67	.205	41	.126	985	3.022	77	1.168	1,062	2.710
1899	329,066	66,541	395,607	660	2.006	141	.428	131	.398	93	.283	82	.249	44	.134	1,151	3.498	90	1.353	1,241	3.137
1900	359,710	72,738	432,448	662	1.840	157	.436	320	.890	121	.336	73	.203	61	.170	1,394	3.875	95	1.306	1,489	3.443
1901	399,935	80,872	480,807	749	1.872	194	.485	153	.382	137	.343	169	.423	67	.168	1,469	3.673	105	1.298	1,574	3.274
1902	424,399	85,818	510,217	726	1.711	188	.443	433	1.020	130	.306	98	.231	60	.141	1,635	3.852	89	1.037	1,724	3.379
1903	462,964	93,617	556,581	920	1.987	221	.478	287	.620	196	.423	88	.190	64	.138	1,776	3.836	150	1.602	1,926	3.460
1904	476,932	96,441	573,373	935	1.961	215	.451	301	.631	190	.398	108	.226	99	.208	1,848	3.875	147	1.524	1,995	3.479
1905	511,863	103,505	615,368	1,095	2.139	247	.482	350	.684	181	.354	117	.229	78	.152	2,068	4.040	164	1.584	2,232	3.627
1906	524,269	106,014	630,283	1,040	1.984	256	.488	265	.506	197	.376	110	.210	92	.175	1,960	3.739	178	1.679	2,138	3.392
1907	561,143	113,470	674,613	1,190	2.120	344	.613	956	1.704	221	.394	227	.405	86	.153	3,094	5.389	218	1.921	3,312	4.806
1908	564,687	114,186	678,873	1,113	1.971	312	.553	375	.664	203	.359	206	.365	77	.136	2,286	4.048	159	1.392	2,445	3.602
1909	554,424	112,111	666,535	1,229	2.216	307	.554	295	.532	191	.345	423	.763	47	.085	2,492	4.495	150	1.338	2,642	3.964
1910	603,080	121,950	725,030	1,314	2.178	380	.630	497	.824	195	.323	171	.284	80	.133	2,637	4.372	184	1.509	2,821	3.891
1911	605,835	122,513	728,348	1,259	2.078	382	.631	365	.602	160	.264	268	.442	52	.086	2,486	4.103	170	1.388	2,656	3.647
1912	601,119	121,543	722,662	1,186	1.973	371	.617	290	.482	147	.244	165	.274	61	.101	2,220	3.693	199	1.637	2,419	3.347
1913	622,109	125,535	747,644	1,264	2.032	424	.681	514	.826	138	.222	222	.357	62	.100	2,624	4.218	161	1.283	2,785	3.725
1914	639,334	123,851	763,185	1,131	1.769	380	.594	349	.546	146	.228	194	.304	88	.138	2,288	3.579	166	1.340	2,454	3.215

[a] In 1911 the bureau collected statistics showing underground and surface employees as separate items. For this particular year the underground employees represented 83.18 per cent of the total and the surface employees 16.82 per cent. Inasmuch as there are no records prior to 1911 in which the surface and underground employees are shown separately, these items have been calculated on the basis of the 1911 returns as shown in this table. The 1914 figures were collected by the United States Geological Survey for both surface and underground employees.

[b] Mineral Resources, U. S. Geol. Survey, except 1909 (Bureau of Census) and 1911 (Bureau of Mines).

TABLE 7.—AVERAGE PRODUCTION, NUMBER OF MEN EMPLOYED, NUMBER OF FATALITIES AND RATES, AND DAYS WORKED IN THE COAL MINES IN THE UNITED STATES, BY STATES, FOR PERIODS DURING WHICH CONTINUOUS RECORDS ARE AVAILABLE.

State.	Period.	Production (short tons).	Number employed.	Number killed.				Production per death (short tons).	Days worked.	Average tonnage per man.		See Table No.
				Average per year.	Per 1,000 employed.	Per 1,000 200-day workers.	Per million tons mined.			Per year.	Per day.	
Alabama	1893–1913	10,533,707	16,863	88.62	5.25	4.39	8.41	118,865	239	625	2.62	85
Arkansas	1905–1913	2,141,396	4,919	11.89	2.42	3.08	5.55	180,117	157	435	2.77	87
Colorado	1886–1913	6,008,413	8,693	62.07	7.14	6.21	10.33	96,798	230	691	3.00	91
Georgia	1909–1913	207,356	461	1.40	3.03	2.29	6.75	148,111	265	450	1.70	93
Illinois	1885–1913	29,611,311	46,707	117.55	2.52	2.50	3.97	251,900	202	634	3.14	95
Indiana	1895–1913	10,401,629	16,581	35.74	2.16	2.31	3.44	291,002	187	627	3.35	97
Iowa	1888–1913	5,675,758	12,508	27.77	2.22	2.10	4.89	204,390	211	454	2.15	99
Kansas	1893–1913	5,107,848	10,280	25.14	2.45	2.53	4.92	203,153	194	497	2.56	101
Kentucky	1888–1913	7,144,744	12,361	24.42	1.98	1.97	3.42	292,541	201	578	2.88	103
Maryland	1889–1906 1909–1913	4,392,277	5,106	9.57	1.87	1.54	2.18	459,193	243	860	3.54	105
Michigan	1900–1913	1,406,433	3,234	7.00	2.16	2.12	4.98	200,919	204	435	2.13	107
Missouri	1888–1913	3,337,180	8,185	14.54	1.78	1.83	4.36	229,541	195	408	2.09	109
Montana	1900–1913	2,115,567	2,921	11.36	3.89	3.26	5.37	186,276	239	724	3.03	111
New Mexico	1893–1913	1,771,859	2,366	27.05	11.43	9.45	15.27	65,509	242	749	3.10	113
North Dakota	1908–1913	439,876	693	2.16	3.12	2.90	4.93	203,020	215	633	2.94	116
Ohio	1884–1913	19,188,032	31,949	76.40	2.39	2.54	3.98	251,152	188	601	3.20	118
Oklahoma	1893–1913	2,468,508	6,366	34.71	5.45	5.71	14.07	71,111	191	388	2.03	120
Oregon	1909–1913	57,834	223	.60	2.69	2.32	10.37	96,390	232	259	1.12	122
Pennsylvania (anthracite)	1870–1913	50,316,598	117,851	402.64	3.42	3.42	8.00	124,968	200	427	2.14	124
Pennsylvania (bituminous)	1877–1913	69,596,423	89,076	256.03	2.87	2.51	3.68	271,832	229	781	3.41	126
Tennessee	1891–1913	4,454,854	8,689	37.35	4.30	3.77	8.38	119,280	228	513	2.25	128
Texas	1909–1913	2,061,793	4,720	5.00	1.06	.90	2.43	412,359	236	437	1.85	130
Utah	1892–1913	1,440,197	1,744	16.14	9.25	7.28	11.20	89,252	254	826	3.25	132
Virginia	1909–1913	6,959,917	7,880	50.20	6.37	4.92	7.21	138,644	259	883	3.41	134
Washington	1889–1913	2,396,305	4,167	25.60	6.14	4.95	10.68	93,606	248	575	2.32	136
West Virginia	1885–1913	26,299,767	32,955	163.72	4.97	4.52	6.23	160,635	220	798	3.63	138
Wyoming	1908–1913	6,820,359	7,716	40.17	5.21	4.49	5.89	169,801	232	884	3.81	140

Figures for the total production of coal in the United States from 1807 to the end of 1914, and the total number of men employed in the industry since 1889 are given in Table 2 and are plotted in figure 1. The table and the figure show the total number of men killed in and about the coal mines in the United States for which complete records are available. It will be noted that in 1870 the percentage of the industry covered by the mine-inspection service (fig. 2), based on the production, was 47.42 with 35,600 men employed. The figures for the total number of men employed are not available. In 1871 the percentage of the industry represented by the production was 41.25 with 37,488 men employed. The figures for the first four years, 1870 to 1873, include only the anthracite mines of Pennsylvania. From 1874 on, a number of other States adopted inspection service, so that by the close of 1888, 87.29 per cent of the production was from States having inspection and representing 285,517 men. The first complete record of the number of men employed in all of the coal-mining States was in 1889, when 311,717 men were employed. Of this number, 283,198, or 90.85 per cent, were employed under the inspection service. The percentage of the production represented by in-

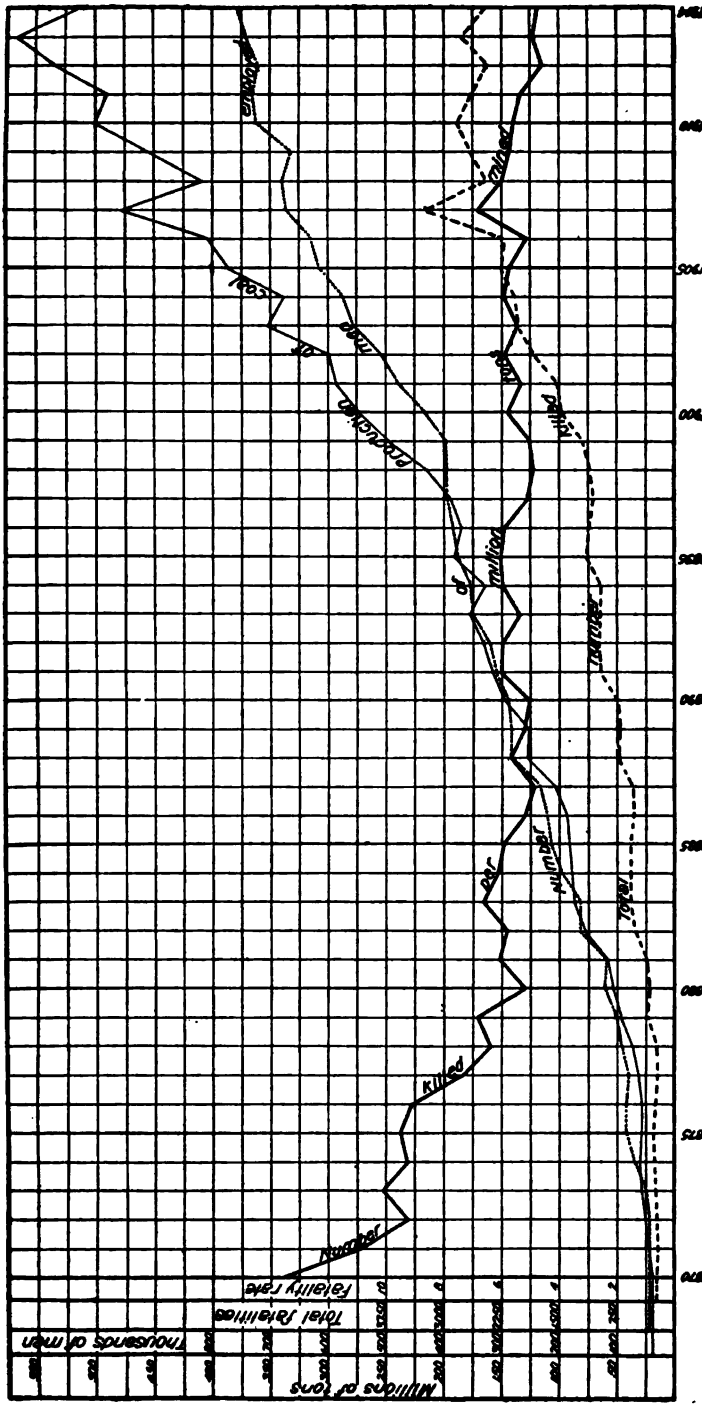
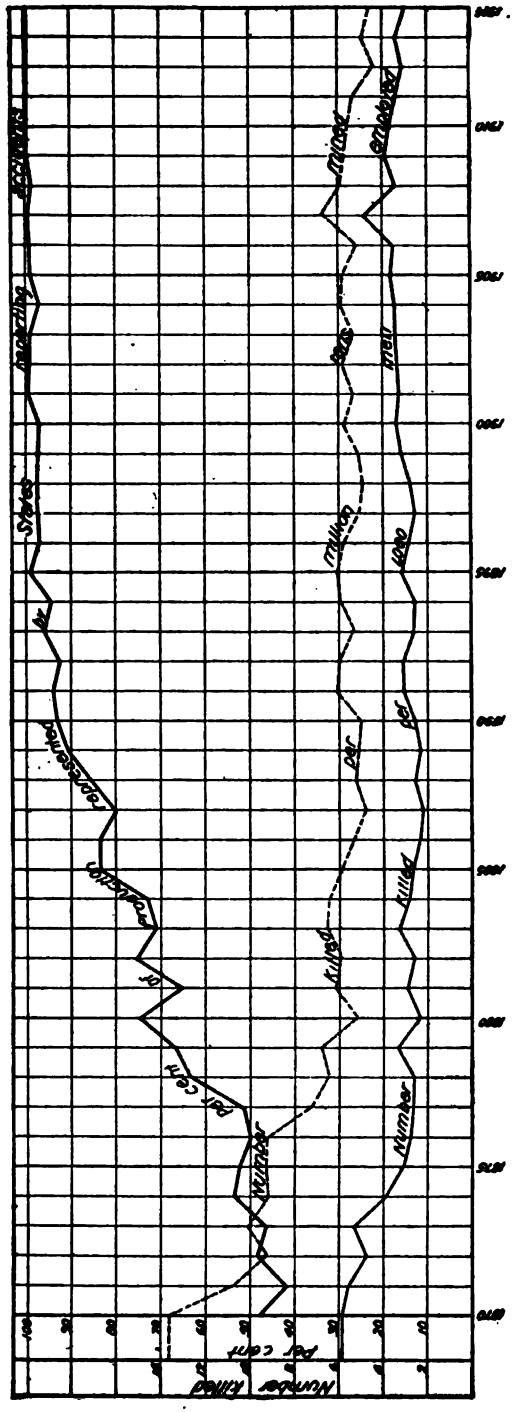


FIGURE 1.—Production, number of men employed, fatalities, and number killed per million tons mined, in coal mines of United States, for which complete returns are available 1870–1914. (Based on Table 2.)


Number killed
Per cent
Number killed per million tons mined
Number killed per million tons mined
Number killed per million tons mined
Per cent of reduction represented by
Number killed per million tons mined
Number killed per million tons mined
Number killed per million tons mined

spection States for the same year was 90.54. From 1889 to date the percentage of production and the number of men employed under inspection service agree with each other within less than 1 per cent. Beginning with 1910 complete figures are available for all of the States, thus representing 100 per cent of the industry. Beginning with 1870, the fatality rate per million tons mined was 13.47 (see fig. 2). This has been gradually reduced until in 1914 it was 4.78. The average amount of coal produced per man per year in 1870 was 440 tons, whereas in 1913 it was 762 tons, and in 1914, 673 tons. Although the figure for tons per man per year was less in 1914 than in 1913, the figure for tons mined per day per man was 3.25 in 1914 as compared with 3.20 in 1913.

Table 2A shows the number of men employed in and about the coal mines by States and calendar years from 1889 to 1914 inclusive.

Table 3 shows the total number of fatalities in the inspection States, for which reports were issued, by calendar years and causes, from 1870 to the end of 1914. This table is a summary of the State tables presented in Part II of this bulletin, as compiled from the State mine inspectors' reports.

Table 4 shows coal-mine fatalities by principal causes, the total number of fatalities, the percentage of the grand total, and the number killed per 1,000 employed (see fig. 3) for a period of 44 years, from 1870 to and including 1913. During this period 23,260 men were killed by falls of roof and pillar coal. The fatalities due to falls of roof and pillar coal in 1870 were 1.60 per 1,000 men employed, while in 1913 it was 1.69. There seems to be but little variation from these figures throughout the 44-year period, the average being 1.554.

Fatalities due to mine cars and locomotives (fig. 3) in the earlier years of inspection service show a slight decrease to about the year 1885. In 1885 the percentage of fatalities due to mine cars and locomotives was 8.01, or 0.206 per 1,000 men employed. Both the percentage and the rate per 1,000 men employed have increased until in 1913 the total percentage was 15.22, while the number killed per 1,000 employed was 0.567.

With reference to gas and dust explosions (fig. 3) both the percentage of the fatalities and the rate per 1,000 men employed are erratic. The lowest figure was in 1887, when 4.36 per cent of the total number of fatalities was due to gas and dust explosions, or practically one fatality per 10,000 men employed. This rate has increased in an irregular manner, reaching the highest point in 1907, when the total percentage of fatalities due to this cause was 29.49, or 1.417 fatalities per 1,000 men employed. Since 1907 there has been some reduction in both percentage and the rate per 1,000 men employed, but this is irregular and in all cases higher than it should be.

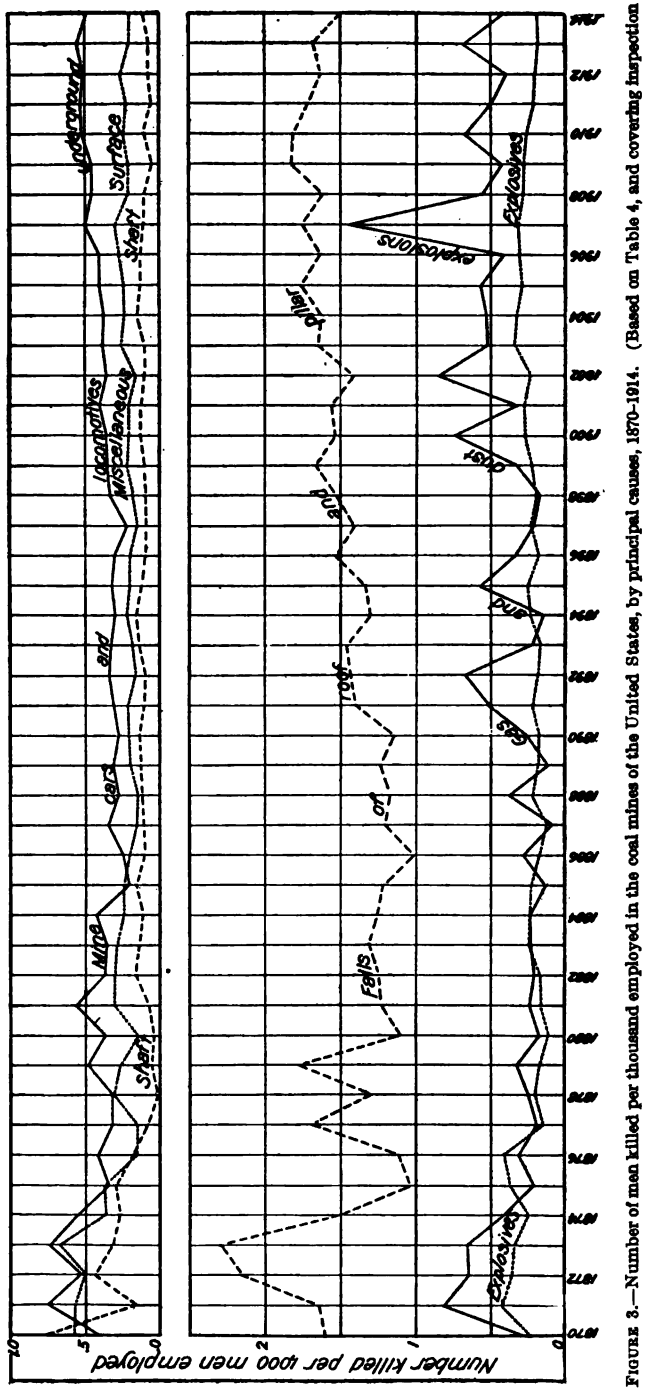


FIGURE 3.—Number of men killed per thousand employed in the coal mines of the United States, by principal causes, 1870–1914. (Based on Table 4, and covering inspection States only.)

Accidents due to explosives also show a decrease from the beginning of inspection to about 1887. From 1887 to 1903 there was an increase, and from 1903 to date the rate has gradually declined.

The fatalities due to shaft accidents (fig. 3) are gradually decreasing, the rate per 1,000 men employed in 1870 being 0.758, while in 1913 it was 0.083.

Table 5 contains the same grouping by causes as does Table 4. It, however, shows fatality rates by States for continuous periods for which records have been published. It contains 1,279 less fatalities than Table 4, by reason of the fact that intermittent records prior to the period of continuous records have been omitted. (See Pls. I and II.)

REDUCTION IN FATALITY RATES AND THE GROWTH OF MINE-INSPECTION SERVICE COMPARED.

The relation between mine-inspection service and the fatality rates at coal mines from 1870 to date is shown in figure 2. The upper curve represents the actual percentage of coal produced under inspection service to the close of 1909. From 1910 to 1914 the Bureau of Mines has received accident reports direct from the operators in those States wherein there is no mine inspection. These States are California, Georgia, Idaho, North Carolina, and Oregon. The coal produced in the noninspection States is less than 0.1 per cent of the total so that the curve from 1910 to 1914 may be accepted as representing the inspection service.

In 1869, 179 men were killed in a mine fire at Avondale, Pa. The following year a law provided for systematic inspection of the anthracite mines. Pennsylvania was therefore the first State to establish a mine-inspection system. From 1870 to 1873 the curve shown represents the anthracite fields only. The fatality rate in 1870 in the anthracite mines was 5.93 per 1,000 men employed, whereas the number of fatalities per million tons mined was 13.47. Corresponding figures for 1914 for the Pennsylvania anthracite field are 3.31 fatalities per 1,000 men employed, and 6.55 fatalities per million tons mined. There are no records to show what the fatality rate in anthracite mines was for years previous to 1870. It was, however, high in 1869, on account of the Avondale disaster. The year 1870 was apparently normal as shown by the actual number of men killed in the anthracite field during the next few years, so that the number of fatalities in 1869 must have been more than 350, with not to exceed 35,000 men employed.

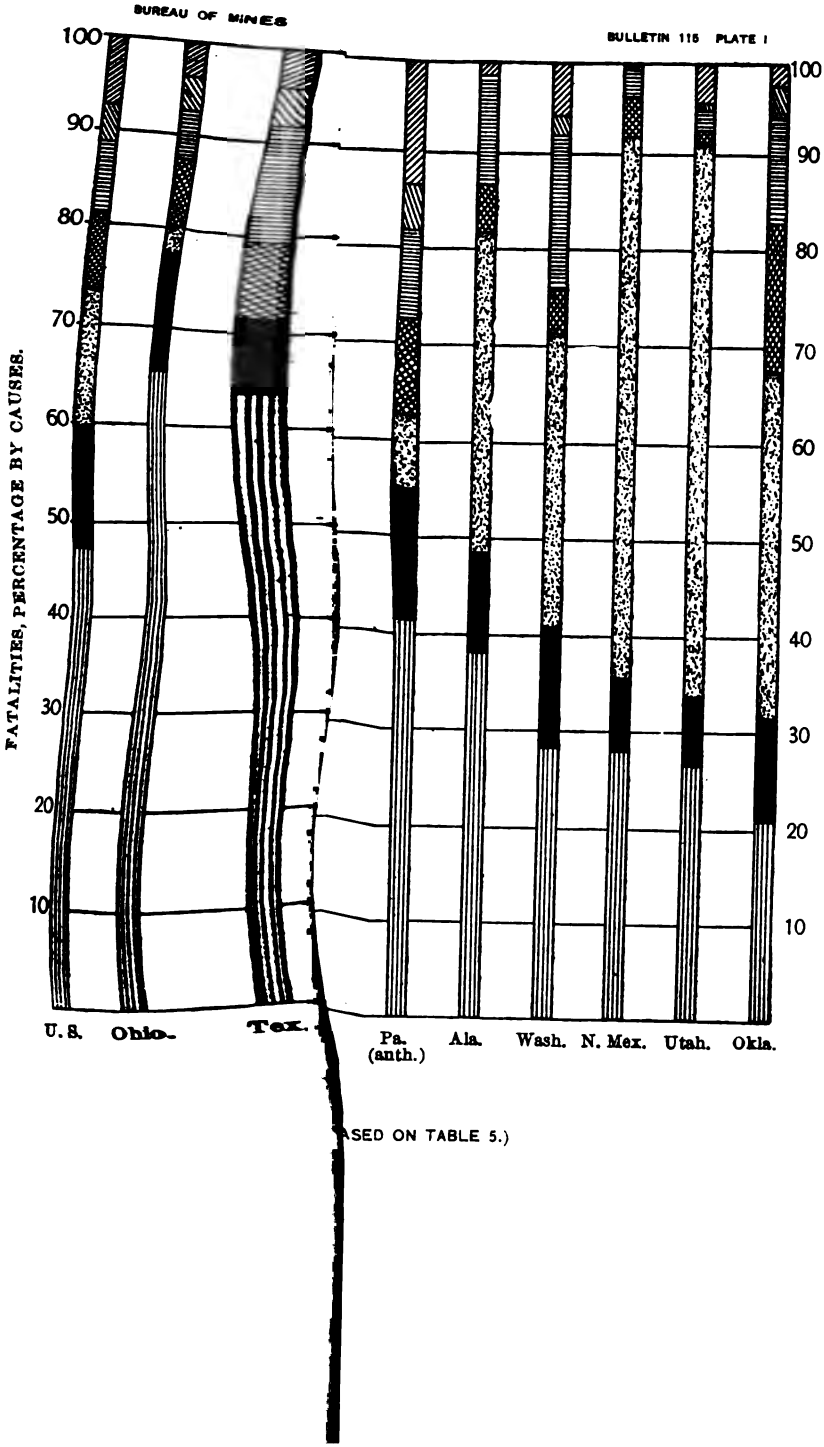
The next State to appoint a mine inspector was Ohio, in 1874, and the first complete inspection year for the Pennsylvania bituminous mines was in 1878, so that after 1874 other States have been added to the inspection list.

Tables 8 to 39 show by years the number of inspection States for which complete records have been obtained, and it is upon these tables that the totals shown in Table 2 and the curves in figure 2 have been based.

During the first 10 years (fig. 2) of mine inspection the fatality rate per 1,000 men employed and the number of fatalities per million tons of coal mined declined rapidly. From 1880 to 1897 the fatality rate per 1,000 men employed remained practically stationary, while the number of fatalities per million tons mined showed a very slight reduction. From 1897 to 1907 the number killed per 1,000 employed increased considerably, reaching the highest point in 1907. Since that year there has been a marked decline.

The increase in the fatality rate from 1897 to 1907 is not necessarily due to less efficient mine inspection. The conditions under which mines were operated were changing. The mines were growing deeper; there were more old abandoned workings for accumulation of gas and dust; and more men were employed in the individual mines than in former years; so that in case of a gas or dust explosion, the likelihood of trapping more men was greater by reason of a larger number of men being employed. During this period there was an influx of foreign laborers, many of whom came from the agricultural districts of southeastern Europe. They had no experience in mining, did not know the English language, and hence were not capable of understanding and carrying out orders that were made in a tongue foreign to them. Although the inspection service has been increasing in efficiency from year to year, the various hazards, for the reasons mentioned, are also increasing.

The increasing fatality rate due to mine disasters, from 1897 and culminating with 1907, has been the means of the passage of more stringent laws concerning the operation of coal mines. Every disaster is thoroughly investigated by State and Federal authorities, as well as by the local engineers of the operating company, to determine the exact cause, so that similar disasters may be prevented in the future. States are establishing rescue and first-aid stations, and nearly every large mining company has its safety engineer and safety-first committees with the necessary rescue and first-aid equipment. An educational campaign on mine-accident prevention has been conducted since 1907 with the result that there is much closer cooperation of miner, foreman, operator, and inspector than in former years. Permissible explosives and improved types of safety lamps have been introduced into many of the mines. Explosibility of coal dust has been studied and precautions adopted to render the dust inert. The work of these various agencies has resulted in a gradual decline in the fatality rate from 1907 to 1914.



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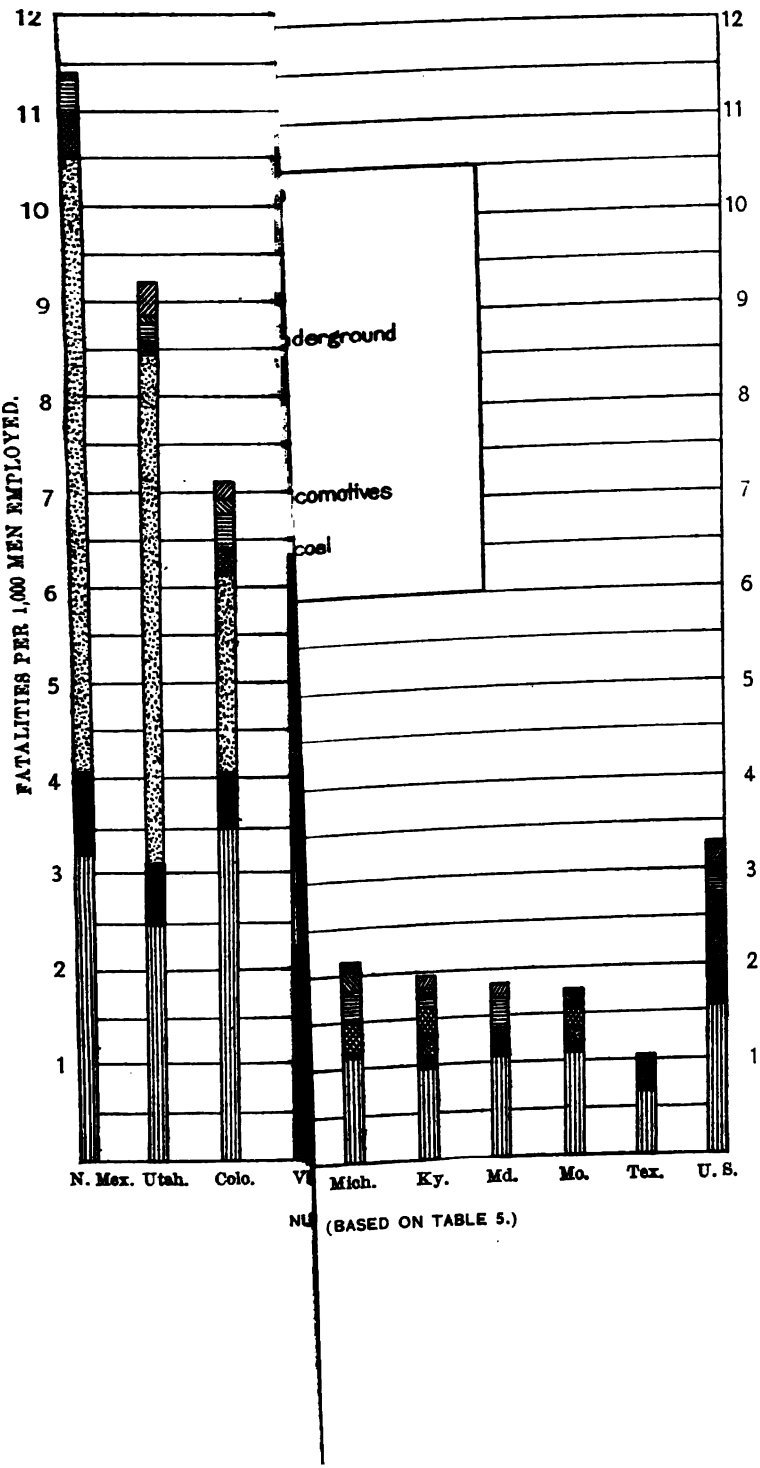

(BASED ON TABLE 5.)

COAL-MINE FATALITIES, BY YEARS AND CAUSES, FROM THE BEGINNING OF INSPECTION IN 1870 TO 1914.

Tables 8 to 39, inclusive, show by causes and calendar years all of the fatalities occurring in and about the coal mines in the United States by combining those States for which there are complete inspection records. In the compilation of these tables all fatalities have been omitted for which the corresponding number of employees was not given. Thus one State may appear in a certain year and not in another simply because the records were incomplete. With reference to fatalities from 1870 to 1873, inclusive, which are represented only by the anthracite mines of Pennsylvania, the reader is referred to Table 125 under that State. The percentage of the industry covered by these tables, the number of men employed, and the fatality rate per 1,000 men employed, and per million tons of coal mined are shown in Table 2

TABLE 3.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEARS 1870–1914, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE. (FOR STATES HAVING COMPLETE INSPECTION RECORDS.[a])

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.	(For States making up total for each year, see table indicated below).
	Falls of roof (coal, rock, etc.)	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).[b]	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.		
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22			Table No.
1870	12	45	15	10	.....	8	1	....	1	....	....	71	163	4	....	23	....	27	1	....	8	5	4	3	21	211	125
1871	18	44	28	31	.....	16	4	....	1	....	20	20	159	5	....	....	1	6	4	....	12	1	....	5	22	210	125
1872	48	49	24	29	.....	16	2	....	....	....	....	11	179	13	2	5	....	20	9	....	8	....	....	7	24	223	125
1873	47	64	36	32	.....	16	....	....	3	....	....	16	214	13	1	2	....	16	14	....	8	....	3	8	33	263	125
1874	60	42	37	28	.....	16	4	....	5	....	....	24	216	8	3	7	1	19	8	....	5	7	....	5	25	260	8
1875	61	28	28	17	.....	33	1	....	....	....	....	33	201	15	4	7	....	26	6	....	14	3	3	7	33	260	8
1876	54	43	36	27	.....	35	2	....	1	....	....	14	212	9	....	6	....	15	5	....	5	1	1	3	15	242	8
1877	73	64	27	16	.....	13	1	....	1	....	....	8	203	4	....	4	....	8	5	....	3	....	1	5	14	225	8
1878	75	42	30	22	.....	18	4	....	2	....	....	11	204	1	1	....	....	2	6	....	7	8	1	7	29	235	9
1879	112	58	47	33	.....	17	....	....	1	....	....	16	284	5	1	1	....	7	10	....	7	....	4	5	26	317	9
1880	99	39	47	22	.....	15	4	....	3	....	....	18	247	6	....	1	....	7	7	....	8	....	1	4	20	274	9
1881	102	42	66	28	.....	19	3	....	6	....	....	29	295	6	....	1	2	9	12	....	14	3	2	5	36	340	9
1882	150	55	61	34	.....	28	1	....	2	....	3	35	369	14	8	6	....	28	15	....	15	1	8	12	51	448	9
1883	170	43	59	37	.....	40	2	....	6	....	....	110	467	15	3	7	....	25	18	....	12	4	6	10	50	542	10
1884	184	59	82	44	.....	43	5	....	1	....	7	40	465	14	3	7	....	24	3	....	11	6	10	19	49	538	10
1885	197	66	44	30	.....	47	11	....	2	....	....	60	457	17	7	14	....	33	15	....	13	9	10	7	54	549	11
1886	173	62	54	60	.....	38	11	....	3	....	....	20	421	13	5	6	....	24	11	....	11	6	5	16	49	494	11
1887	180	96	79	22	.....	28	10	....	5	....	1	17	438	18	3	6	1	28	10	....	11	1	5	11	38	504	12
1888	255	81	82	22	84	65	3	....	6	....	....	48	646	17	7	14	....	38	8	....	9	4	9	14	44	728	13
1889	265	87	90	33	.....	46	8	....	3	....	....	36	568	9	1	27	4	41	16	....	11	8	10	14	59	668	14
1890	262	78	84	76	.....	48	7	....	8	....	34	27	634	21	4	20	....	45	21	....	10	9	9	15	64	743	15
1891	345	94	98	158	5	72	13	....	4	....	5	54	845	18	4	15	....	37	16	....	14	7	10	24	71	956	16
1892	349	108	110	111	104	60	....	....	3	....	2	55	902	20	4	11	....	35	20	....	12	....	7	15	54	991	17
1893	412	106	118	53	32	62	....	....	6	....	14	35	838	27	6	17	2	52	15	....	16	4	11	22	68	958	18

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TABLE 4.—COAL-MINE FATALITIES IN THE UNITED STATES BY PRINCIPAL CAUSES, 1870-1914 (FOR INSPECTION STATES ONLY).

[See fig. 3.]

Year.	Falls of roof and pillar coal. (1 and 2)			Mine cars and locomotives. (3)			Gas and dust explosions. (4 and 5)			Explosives. (6)			Miscellaneous underground. (7 to 12)			Total shaft fatalities. (13 to 16)			Total surface fatalities. (17 to 22)			Grand total.		Number of men employed.[a]
	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.	
1870	57	27.01	1.601	15	7.11	0.421	10	4.74	0.281	8	3.79	0.225	73	34.60	2.051	27	12.80	0.758	21	9.95	0.590	211	5.927	35,600
1871	62	29.52	1.654	28	13.33	.747	31	14.76	.827	16	7.62	.427	45	21.43	1.200	6	2.86	.160	22	10.48	.587	210	5.602	37,488
1872	97	43.50	2.168	24	10.76	.536	29	13.00	.648	16	7.18	.358	13	5.83	.291	20	8.97	.447	24	10.76	.536	223	4.984	44,745
1873	111	42.21	2.303	36	13.69	.747	32	12.17	.664	16	6.08	.332	19	7.22	.394	16	6.08	.332	33	12.55	.685	263	5.457	48,199
1874	102	39.23	1.519	37	14.23	.551	28	10.77	.417	16	6.15	.238	33	12.69	.492	19	7.31	.283	25	9.62	.372	260	3.872	67,152
1875	89	34.23	1.047	28	10.77	.329	17	6.54	.200	33	12.69	.388	34	13.08	.400	26	10.00	.306	33	12.69	.388	260	3.058	85,005
1876	97	40.08	1.135	36	14.88	.421	27	11.16	.316	35	14.46	.410	17	7.02	.199	15	6.20	.175	15	6.20	.175	242	2.831	85,474
1877	137	60.89	1.688	27	12.00	.333	16	7.11	.197	13	5.78	.160	10	4.44	.123	8	3.56	.099	14	6.22	.173	225	2.773	81,142
1878	117	49.79	1.304	30	12.77	.334	22	9.36	.245	18	7.66	.201	17	7.23	.189	2	0.85	.022	29	12.34	.323	235	2.618	89,751
1879	170	53.63	1.768	47	14.83	.489	33	10.41	.343	17	5.36	.177	17	5.36	.177	7	2.21	.073	26	8.20	.271	317	3.298	96,133
1880	138	50.37	1.115	47	17.15	.380	22	8.03	.178	15	5.47	.121	25	9.13	.202	7	2.55	.056	20	7.30	.162	274	2.214	123,736
1881	144	42.35	1.240	66	19.41	.568	28	8.23	.241	19	5.59	.164	38	11.18	.327	9	2.65	.078	36	10.59	.310	340	2.928	116,128
1882	205	45.76	1.258	61	13.62	.374	34	7.59	.209	28	6.25	.172	41	9.15	.252	28	6.25	.172	51	11.38	.313	448	2.750	162,883
1883	213	39.30	1.313	59	10.89	.364	37	6.83	.228	40	7.38	.247	118	21.77	.727	25	4.61	.154	50	9.22	.308	542	3.341	162,248
1884	243	45.17	1.263	82	15.24	.426	44	8.18	.229	43	7.99	.224	53	9.85	.275	24	4.46	.125	49	9.11	.255	538	2.797	192,369
1885	263	47.91	1.234	44	8.01	.206	30	5.46	.141	47	8.56	.220	73	13.30	.343	38	6.92	.178	54	9.84	.253	549	2.575	213,178
1886	235	47.57	1.070	54	10.93	.246	60	12.15	.273	38	7.69	.173	34	6.88	.155	24	4.86	.109	49	9.92	.223	494	2.249	219,699
1887	276	54.76	1.207	79	15.67	.345	22	4.36	.096	28	5.56	.123	33	6.55	.144	28	5.56	.122	38	7.54	.166	504	2.203	228,777
1888	336	46.16	1.177	82	11.26	.287	106	14.56	.371	65	8.93	.228	57	7.83	.200	38	5.22	.133	44	6.04	.154	728	2.550	285,517
1889	352	52.69	1.243	90	13.47	.318	33	4.94	.117	46	6.89	.162	47	7.04	.166	41	6.14	.145	59	8.83	.208	668	2.359	283,198
1890	340	46.38	1.168	84	11.46	.288	76	10.37	.261	48	6.55	.165	76	10.37	.261	45	6.14	.154	64	8.73	.220	733	2.517	291,217
1891	439	45.92	1.413	98	10.25	.315	163	17.05	.525	72	7.53	.232	76	7.95	.245	37	3.87	.119	71	7.43	.228	956	3.077	310,683
1892	457	46.12	1.441	110	11.10	.347	215	21.70	.678	60	6.05	.189	60	6.05	.189	35	3.53	.111	54	5.45	.170	991	3.125	317,140
1893	518	54.07	1.459	118	12.32	.332	85	8.87	.239	62	6.47	.175	55	5.74	.155	52	5.43	.146	68	7.10	.192	958	2.698	355,091
1894	474	49.48	1.322	109	11.38	.304	55	5.74	.153	86	8.98	.240	93	9.71	.259	58	6.05	.162	83	8.66	.231	958	2.671	358,642
1895	503	44.05	1.338	123	10.77	.327	225	19.70	.599	99	8.67	.263	64	5.60	.170	49	4.29	.130	79	6.92	.210	1,142	3.037	376,024
1896	583	53.83	1.532	119	10.99	.313	128	11.82	.336	72	6.65	.189	60	5.54	.158	41	3.78	.108	80	7.39	.210	1,083	2.846	380,477
1897	559	56.47	1.439	96	9.70	.247	82	8.28	.211	88	8.89	.227	63	6.36	.162	39	3.94	.100	63	6.36	.162	990	2.548	388,585
1898	601	56.59	1.534	132	12.43	.337	69	6.50	.176	75	7.06	.191	67	6.31	.171	41	3.86	.105	77	7.25	.196	1,062	2,710	391,841
1899	660	53.18	1.668	141	11.36	.357	131	10.56	.331	93	7.49	.235	82	6.61	.207	44	3.55	.111	90	7.25	.228	1,241	3.137	395,607

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TABLE 5.—COAL-MINE FATALITIES, BY STATES AND PRINCIPAL CAUSES, DURING PERIODS ENDING DEC. 31, 1913, FOR WHICH CONTINUOUS RECORDS ARE AVAILABLE.

[See Pls. I and II.]

State.	Period ending 1913.	Falls of roof and pillar coal. (1 and 2)			Mine cars and locomotives. (3)			Gas and dust explosions. (4 and 5)			Explosives. (6)			Miscellaneous underground. (7 to 12)			Total shaft fatalities. (13 to 16)			Total surface fatalities. (17 to 22)			Number killed.	
		Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Total.	Per 1,000 employed.
	Yrs.																							
Alabama	21	713	38.31	2.01	193	10.37	0.55	620	33.32	1.75	96	5.16	0.27	203	10.91	0.57	8	0.43	0.02	28	1.50	0.08	1,861	5.25
Arkansas	9	65	60.75	1.46	2	1.87	.05	2	1.87	.05	15	14.01	.34	20	18.69	.45	2	1.87	.05	1	.94	.02	107	2.42
Colorado	28	852	49.02	3.50	141	8.11	.58	517	29.75	2.12	60	3.45	.25	83	4.78	.34	36	2.07	.15	49	2.82	.20	1,738	7.14
Georgia	5	6	85.71	2.60	0	.....	.....	0	.....	.....	1	14.29	.43	0	.....	.....	0	.....	.....	0	.....	.....	7	3.03
Illinois	29	1,616	47.40	1.19	414	12.14	.30	170	4.99	.13	459	13.47	.34	350	10.27	.26	266	7.80	.20	134	3.93	.10	3,409	2.53
Indiana	19	330	45.07	.97	75	11.04	.24	57	8.39	.18	132	19.44	.42	22	3.24	.07	71	10.46	.23	16	2.36	.05	679	2.16
Iowa	26	426	59.00	1.31	76	10.53	.23	44	6.10	.13	74	10.25	.23	18	2.49	.06	65	9.00	.20	19	2.63	.06	722	2.22
Kansas	21	259	49.05	1.20	12	2.27	.06	33	6.25	.15	131	24.81	.61	26	4.93	.12	50	9.47	.23	17	3.22	.08	528	2.45
Kentucky	26	316	49.76	.98	46	7.25	.14	74	11.65	.23	89	14.02	.28	39	6.14	.12	24	3.78	.08	47	7.40	.15	635	1.98
Maryland	23	127	57.73	1.08	30	13.64	.25	0	.....	.....	5	2.27	.04	36	16.36	.31	0	.....	.....	22	10.00	.19	220	1.87
Michigan	14	51	52.04	1.13	2	2.04	.04	0	.....	.....	15	15.31	.33	15	15.31	.33	10	10.20	.22	5	5.10	.11	98	2.16
Missouri	26	235	62.17	1.10	19	5.03	.09	40	10.58	.19	43	11.38	.20	10	2.64	.05	27	7.14	.13	4	1.06	.02	378	1.78
Montana	14	88	55.34	2.15	23	14.47	.56	0	.....	.....	11	6.92	.27	27	16.98	.66	1	.63	.03	9	5.66	.22	159	3.89
New Mexico	21	160	28.17	3.22	43	7.57	.87	321	56.51	6.46	24	4.23	.48	16	2.82	.32	0	.....	.....	4	.70	.08	568	11.42
North Dakota	6	6	40.16	1.44	2	15.38	.48	0	.....	.....	3	23.08	.72	2	15.38	.48	0	.....	.....	0	.....	.....	13	3.12
Ohio	30	1,509	65.84	1.57	277	12.08	.29	64	2.79	.07	161	7.02	.17	115	5.02	.12	79	3.45	.08	87	3.80	.09	2,292	2.39
Oklahoma	21	153	20.99	1.14	78	10.70	.58	262	35.94	1.96	115	15.77	.86	79	10.84	.59	25	3.43	.19	17	2.33	.13	729	5.45
Oregon	5	1	33.33	.90	0	.....	.....	2	66.67	1.79	0	.....	.....	0	.....	.....	0	.....	.....	0	.....	.....	3	2.69
Pennsylvania (anthracite)	44	7,378	41.65	1.42	2,403	13.56	.46	1,344	7.59	.26	1,790	10.10	.35	1,637	9.24	.32	843	4.76	.16	2,321	13.10	.45	17,716	3.42
Pennsylvania (bituminous)	36	5,393	56.93	1.64	1,452	15.33	.44	1,309	13.82	.40	185	1.95	.05	512	5.40	.16	217	2.29	.06	405	4.28	.12	9,473	2.87
Tennessee	23	361	42.03	1.81	49	5.70	.25	339	39.47	1.70	49	5.70	.25	27	3.14	.13	1	.12	.....	33	3.84	.16	859	4.30
Texas	5	16	64.00	.67	2	8.00	.08	0	.....	.....	2	8.00	.09	3	12.00	.13	1	4.00	.04	1	4.00	.04	25	1.06
Utah	22	95	26.76	2.48	25	7.04	.65	205	57.75	5.34	5	1.40	.13	7	1.97	.18	3	.84	.08	15	4.23	.39	355	9.25
Virginia	5	131	52.19	3.33	32	12.75	.81	25	9.96	.63	10	3.98	.25	34	13.55	.86	1	.40	.03	18	7.17	.46	251	6.37
Washington	25	182	28.44	1.75	81	12.65	.78	195	30.47	1.87	32	5.00	.30	102	15.94	.98	13	2.03	.12	35	5.47	.33	640	6.14
West Virginia	29	2,452	51.64	2.57	557	11.73	.58	1,036	21.82	1.09	155	3.27	.16	202	4.25	.21	67	1.41	.07	279	5.88	.29	4,748	4.97
Wyoming	6	114	47.30	2.46	22	9.13	.48	67	27.80	1.45	13	5.40	.28	17	7.05	.37	1	.41	.02	7	2.91	.15	241	5.21
Total	.....	23,011	47.49	1.57	6,056	12.50	.42	6,726	13.88	.46	3,675	7.59	.25	3,608	7.43	.25	1,611	3.74	.12	3,573	7.37	.24	48,454	3.21

TABLE 6.—FATALITY RATES IN AND ABOUT THE COAL MINES IN THE UNITED STATES BASED ON UNDERGROUND AND SURFACE EMPLOYEES.[a]

Year.	Number employed.			Number killed.															
				Underground.												Surface.		Total.	
				Falls of roof and pillar coal. (1 and 2)		Mine cars and locomotives. (3)		Gas and dust explosions. (4 and 5)		Explosives. (6)		Miscellaneous underground. (7 to 12)		Shaft. (13 to 16)		Underground (total).		(17 to 22)	
	Underground.[a]	Surface.[a]	Total.[b]	Number killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.
1895	312,777	63,247	376,024	503	1.608	123	0.393	225	0.719	99	0.317	64	0.205	49	0.157	1,063	3.399	79	1.249
1896	316,481	63,996	380,477	583	1.842	119	.376	128	.404	72	.227	60	.190	41	.130	1,003	3.169	80	1.250
1897	323,225	65,360	388,585	550	1.729	96	.297	82	.254	88	.272	63	.195	39	.121	927	2.868	63	.964
1898	325,933	65,908	391,841	601	1.844	132	.405	69	.212	75	.230	67	.205	41	.126	985	3.022	77	1.168
1899	329,066	66,541	395,607	660	2.006	141	.428	131	.398	93	.283	82	.249	44	.134	1,151	3.498	90	1.353
1900	359,710	72,738	432,448	662	1.840	157	.436	320	.890	121	.336	.73	.203	61	.170	1,394	3.875	95	1.306
1901	399,935	80,872	480.807	749	1.872	194	.485	153	.382	137	.343	169	.423	67	.168	1,469	3.673	105	1.298
1902	424,399	85,818	510,217	726	1.711	188	.443	433	1.020	130	.306	98	.231	60	.141	1,635	3.852	89	1.037
1903	462,964	93,617	556,581	920	1.987	221	.478	287	.620	196	.423	88	.190	64	.138	1,776	3.836	150	1.602
1904	476,932	96,441	573,373	935	1.961	215	.451	301	.631	190	.398	108	.226	99	.208	1,848	3.875	147	1.524
1905	511,863	103,505	615,368	1,095	2.139	247	.482	350	.684	181	.354	117	.229	78	.152	2,068	4.040	164	1.584
1906	524,269	106,014	630,283	1,040	1.984	256	.488	265	.506	197	.376	110	.210	92	.175	1,960	3.739	178	1.679
1907	561,143	113,470	674,613	1,190	2.120	344	.613	956	1.704	221	.394	227	.405	86	.153	3,004	5.389	218	1.921
1908	564,687	114,186	678,873	1,113	1.971	312	.553	375	.664	203	.359	206	.365	77	.136	2,286	4.048	159	1.392
1909	554,424	112,111	666,535	1,229	2.216	307	.554	295	.532	191	.345	423	.763	47	.085	2,492	4.495	150	1.338
1910	603,080	121,950	725,030	1,314	2.178	380	.630	497	.824	195	.323	171	.284	80	.133	2,637	4.372	184	1.509
1911	605,835	122,513	728,348	1,259	2.078	382	.631	365	.602	160	.264	268	.442	52	.086	2,486	4.103	170	1.388
1912	601,119	121,543	722,662	1,186	1.973	371	.617	290	.482	147	.244	165	.274	61	.101	2,220	3.693	199	1.637
1913	622,109	125,535	747,644	1,264	2.032	424	.681	514	.826	138	.222	222	.357	62	.100	2,624	4.218	161	1.283
1914	639,334	123,851	763,185	1,131	1.769	380	.594	349	.546	146	.228	194	.304	88	.138	2,288	3.579	166	1.340

[a] In 1911 the bureau collected statistics showing underground and surface employees as separate items. For this particular year the underground employees represented 83.18 per cent of the total and the surface employees 16.82 per cent. Inasmuch as there are no records prior to 1911 in which the surface and underground employees are shown separately, these items have been calculated on the basis of the 1911 returns as shown in this table. The 1914 figures were collected by the United States Geological Survey for both surface and underground employees.

[b] Mineral Resources, U. S. Geol. Survey, except 1909 (Bureau of Census) and 1911 (Bureau of Mines).

TABLE 14.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1889, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Arkansas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Colorado	5	4	3	.....	.....	.....	.....	.....	.....	.....	.....	11	23	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	24
Georgia and North Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Illinois	22	5	5	2	.....	3	.....	.....	.....	.....	.....	.....	37	.....	.....	4	.....	4	.....	.....	.....	.....	.....	.....	.....	41
Indiana	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Iowa	11	2	2	.....	.....	2	.....	.....	.....	.....	.....	.....	17	1	.....	4	.....	5	.....	.....	.....	.....	.....	.....	.....	22
Kansas	6	2	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	11	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	12
Kentucky	9	.....	1	.....	.....	2	.....	.....	.....	.....	.....	.....	12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12
Maryland	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5
Michigan	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Missouri	6	1	1	.....	.....	1	.....	.....	.....	.....	.....	.....	9	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	10
Montana	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0
New Mexico	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Ohio	17	7	6	.....	.....	1	.....	.....	.....	.....	.....	.....	31	.....	.....	3	.....	3	.....	.....	.....	.....	.....	.....	.....	34
Oklahoma	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Pennsylvania (anthracite)	128	41	60	24	.....	32	8	.....	3	.....	.....	18	314	6	1	12	1	20	11	.....	11	6	10	13	51	385
Pennsylvania (bituminous)	48	22	10	6	.....	2	.....	.....	.....	.....	.....	2	90	2	.....	2	3	7	4	.....	.....	2	.....	.....	6	103
Tennessee	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Utah	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Washington	1	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	4	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
West Virginia	7	3	2	.....	.....	.....	.....	.....	.....	.....	.....	1	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	14
Wyoming	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Total, 1889	265	87	90	33	.....	46	8	.....	3	.....	.....	26	568	9	1	27	4	41	16	.....	11	8	10	14	59	668

[a] No inspection, or report not published.

TABLE 15.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1890, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama																										(a)
Alaska and California																										(a)
Arkansas																										(a)
Colorado	6	4	1	1		2							14	2				2								16
Georgia and North Carolina																										(a)
Idaho and Nevada																										(a)
Illinois	25	7	1	1		7					3		44		2	6		8				2	2	1	5	57
Indiana												5	5													5
Iowa	4	1	1			3							9	1		1		2					1		1	13
Kansas	4					1							5			3		3								8
Kentucky	7	1				2							10													10
Maryland	4	1	3										8													8
Michigan																										(a)
Missouri	10			1		4							15	1		1		2	1						1	18
Montana		1											1													1
New Mexico																										(a)
North Dakota																										(a)
Ohio	23	7	3	1		2	1					1	38			1		1								39
Oklahoma																										(a)
Oregon																										(a)
Pennsylvania (anthracite)	98	34	57	70		18	5				7	17	306	15	2	7		24	17		10	7	5	9	48	378
Pennsylvania (bituminous)	62	19	16			5					1	31	3	137	2		1		3	2				3	5	145
Tennessee																										(a)
Texas																										(a)
Utah																										(a)
Virginia																										(a)
Washington	1		1	2		1	1					1	7													7
West Virginia	18	3	1			3							25						1				1	2	4	33
Wyoming																										(a)
Total, 1890	262	78	84	76		48	7		8		34	27	624	21	4	20		45	21		10	9	9	15	64	733

a No inspection, or report not published.

TABLE 16.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1891, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Arkansas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Colorado	17	5	2	.....	2	3	.....	.....	.....	.....	.....	1	30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	30
Georgia and North Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Illinois	22	8	1	3	3	4	.....	.....	.....	.....	.....	.....	41	2	.....	2	.....	4	.....	.....	.....	2	1	1	4	49
Indiana	2	.....	1	.....	.....	1	.....	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	5
Iowa	19	2	.....	.....	.....	4	.....	.....	.....	.....	.....	.....	25	.....	.....	1	.....	1	.....	.....	.....	1	.....	.....	1	27
Kansas	7	.....	1	.....	.....	2	.....	.....	.....	.....	.....	1	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11
Kentucky	10	1	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	13	1	.....	1	.....	2	1	.....	.....	.....	.....	.....	1	16
Maryland	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
Michigan	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Missouri	10	2	1	.....	.....	3	1	.....	.....	.....	.....	.....	17	.....	.....	3	.....	3	.....	.....	.....	.....	.....	.....	.....	20
Montana	3	1	2	.....	.....	1	.....	.....	.....	.....	.....	.....	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7
New Mexico	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Ohio	26	4	3	.....	.....	1	.....	.....	1	.....	.....	2	37	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	1	38
Oklahoma	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Pennsylvania (anthracite)	123	44	59	39	.....	41	12	.....	3	.....	2	34	357	13	2	5	....	20	8	....	13	3	7	20	51	428
Pennsylvania (bituminous)	68	18	18	111	.....	5	.....	.....	.....	.....	3	4	227	1	2	3	....	6	2	....	.....	.....	.....	1	3	236
Tennessee	12	1	.....	.....	.....	5	.....	.....	.....	.....	.....	1	19	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	22
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Utah	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Washington	1	2	2	.....	.....	1	.....	.....	.....	.....	.....	5	11	1	.....	.....	.....	1	.....	.....	.....	.....	.....	2	2	14
West Virginia	25	6	6	5	.....	1	.....	.....	.....	.....	.....	.....	43	.....	.....	.....	.....	.....	2	.....	1	.....	1	.....	4	47
Wyoming	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Total, 1891	**345**	**94**	**98**	**158**	**5**	**72**	**13**	.....	**4**	.....	**5**	**54**	**848**	**18**	**4**	**15**	....	**37**	**16**	....	**14**	**7**	**10**	**24**	**71**	**956**

a No inspection, or report not published.

TABLE 17.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1892, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Arkansas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Colorado	11	10	2	2	1	3	.....	.....	.....	.....	.....	.....	29	1	1	2	.....	4	.....	.....	.....	.....	.....	.....	.....	33
Georgia and North Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Illinois	29	12	6	2	.....	4	.....	.....	.....	.....	2	2	57	7	1	4	.....	12	.....	.....	.....	.....	.....	.....	.....	69
Indiana	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19	19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19
Iowa	13	.....	1	.....	3	2	.....	.....	.....	.....	.....	.....	19	1	.....	.....	.....	1	.....	.....	.....	.....	.....	1	1	21
Kansas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Kentucky	4	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	.....	1	.....	.....	1	2	.....	.....	.....	.....	.....	2	8
Maryland	3	1	1	.....	.....	.....	.....	.....	1	.....	.....	.....	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
Michigan	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Missouri	12	2	1	3	.....	2	.....	.....	.....	.....	.....	.....	20	.....	.....	1	.....	1	.....	.....	.....	.....	.....	1	1	22
Montana	1	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3
New Mexico	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Ohio	21	4	5	.....	.....	5	.....	.....	.....	.....	.....	2	37	3	.....	.....	.....	3	1	.....	.....	.....	1	1	3	43
Oklahoma	.....	.....	.....	.....	100	.....	.....	.....	.....	.....	.....	.....	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	100
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Pennsylvania (anthracite)	142	48	54	57	.....	34	.....	.....	2	.....	.....	29	366	7	.....	3	.....	10	15	.....	11	.....	4	12	42	416
Pennsylvania (bituminous)	76	18	31	1	.....	2	.....	.....	.....	.....	.....	.....	128	1	.....	1	.....	2	1	.....	1	.....	2	.....	4	134
Tennessee	10	1	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Utah	1	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Washington	3	.....	3	46	.....	.....	.....	.....	.....	.....	.....	1	53	.....	1	.....	.....	1	1	.....	.....	.....	.....	.....	1	55
West Virginia	23	12	3	.....	.....	5	.....	.....	.....	.....	.....	2	45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	45
Wyoming	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Total, 1892	349	108	110	111	104	60	.....	.....	3	.....	2	55	902	20	4	11	.....	35	20	.....	12	.....	7	15	54	991

a No inspection, or report not published.

TABLE 18.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1893, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.								Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	13	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	1	2	17
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Arkansas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Colorado	13	3	3	.....	24	1	.....	.....	.....	.....	.....	.....	44	.....	.....	1	.....	1	.....	.....	.....	1	.....	.....	1	46
Georgia and North Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Illinois	42	9	5	1	.....	7	.....	.....	.....	.....	.....	.....	64	7	.....	6	1	14	1	.....	.....	1	2	1	5	83
Indiana	9	2	1	3	.....	5	.....	.....	.....	.....	.....	.....	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	2	23
Iowa	12	2	.....	.....	8	1	.....	.....	.....	.....	.....	.....	23	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	24
Kansas	3	.....	1	.....	.....	2	.....	.....	.....	.....	.....	5	11	1	.....	2	.....	3	.....	.....	.....	.....	.....	.....	.....	14
Kentucky	9	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	10	.....	.....	1	.....	1	1	.....	.....	.....	.....	.....	1	12
Maryland	2	2	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5
Michigan	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Missouri	13	1	1	.....	.....	1	.....	.....	.....	.....	.....	.....	16	1	.....	1	.....	2	.....	.....	.....	.....	.....	.....	.....	18
Montana	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
New Mexico	2	1	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Ohio	20	2	5	.....	.....	3	.....	.....	.....	.....	.....	1	31	5	.....	.....	.....	5	.....	.....	.....	.....	.....	.....	.....	36
Oklahoma	2	1	1	1	.....	1	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Pennsylvania (anthracite)	143	46	72	46	.....	38	.....	.....	6	.....	10	23	384	10	6	4	.....	20	10	.....	14	2	8	17	51	455
Pennsylvania (bituminous)	86	19	16	1	.....	2	.....	.....	.....	.....	4	1	129	.....	.....	1	.....	1	1	.....	.....	.....	.....	.....	1	131
Tennessee	3	3	2	.....	.....	.....	.....	.....	.....	.....	.....	3	11	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	2	13
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Utah	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0
Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Washington	4	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	.....	.....	.....	1	1	.....	.....	1	.....	.....	.....	1	9
West Virginia	35	13	7	.....	.....	.....	.....	.....	.....	.....	.....	2	57	3	.....	.....	.....	3	1	.....	.....	.....	.....	1	2	62
Wyoming	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Total, 1893	412	106	118	53	32	62	.....	.....	6	.....	14	35	838	27	6	17	2	52	15	....	16	4	11	22	68	958

a No inspection, or report not published.

TABLE 19.--NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1894, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	11	1	2	.....	.....	2	.....	.....	.....	.....	4	.....	20	....	1	...	.....	1	....	....	....	.....	.....	.....	....	21
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Arkansas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Colorado	11	2	1	1	.....	1	.....	.....	.....	.....	.....	1	17	1	.....	...	.....	1	1	.....	.....	.....	.....	.....	.....	19
Georgia and North Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Illinois	25	3	3	2	.....	14	1	.....	1	.....	.....	.....	49	2	1	2	....	5	.....	.....	1	....	1	1	3	57
Indiana	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Iowa	12	1	3	.....	.....	3	.....	.....	.....	.....	.....	.....	19	1	....	1	....	2	.....	.....	.....	2	1	...	3	24
Kansas	10	.....	.....	.....	2	4	.....	.....	.....	.....	.....	.....	16	3	....	2	....	5	.....	.....	.....	.....	2	1	3	24
Kentucky	6	.....	1	.....	.....	2	.....	.....	.....	.....	.....	.....	9	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	1	10
Maryland	5	1	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7
Michigan	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Missouri	10	1	.....	4	.....	1	1	.....	.....	.....	.....	.....	17	1	.....	.....	.....	1	.....	.....	1	.....	.....	.....	1	19
Montana	5	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
New Mexico	4	.....	.....	6	.....	1	.....	.....	.....	.....	.....	.....	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11
North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Ohio	20	3	2	1	.....	7	.....	.....	.....	.....	.....	.....	33	2	....	3	....	5	.....	.....	.....	1	.....	.....	1	39
Oklahoma	3	.....	2	1	.....	2	.....	.....	.....	.....	.....	.....	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	9
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Pennsylvania (anthracite)	151	30	57	26	.....	44	1	.....	4	.....	7	30	350	15	8	8	....	31	13	....	13	11	7	20	64	445
Pennsylvania (bituminous)	66	25	22	.....	.....	4	.....	.....	.....	.....	.....	.....	117	3	....	3	....	6	.....	.....	.....	.....	.....	.....	.....	123
Tennessee	12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	.....	.....	.....	.....	.....	.....	.....	1	.....	1	.....	2	14
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Utah	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Washington	2	1	4	.....	4	.....	.....	.....	.....	.....	37	1	49	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	50
West Virginia	41	11	11	.....	8	.....	.....	.....	1	.....	2	2	76	1	.....	.....	.....	1	2	.....	.....	.....	.....	.....	2	79
Wyoming	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Total, 1894	395	79	109	41	14	88	3	.....	6	.....	50	34	817	29	10	19	....	58	16	....	16	15	12	24	83	958

a No inspection, or report not published.

TABLE 20.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1895, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	19	4	6	3	.....	2	2	.....	.....	.....	.....	.....	36	1	.....	.....	.....	1	.....	.....	1	.....	.....	1	2	39
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Arkansas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Colorado	6	6	3	4	.....	2	.....	.....	.....	.....	.....	.....	21	.....	.....	.....	2	2	.....	.....	.....	.....	.....	.....	.....	23
Georgia and North Carolina	.....	.....	.....	b 39	.....	.....	.....	.....	.....	.....	.....	.....	39	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	39
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Illinois	32	11	4	.....	.....	7	4	.....	.....	.....	.....	1	59	5	.....	8	1	14	1	.....	1	.....	2	1	5	78
Indiana	12	.....	3	.....	.....	3	.....	.....	.....	.....	.....	.....	18	3	.....	2	.....	5	.....	.....	.....	.....	.....	.....	.....	23
Iowa	11	2	1	.....	.....	.....	4	.....	.....	.....	2	.....	20	2	.....	.....	.....	2	.....	.....	.....	.....	1	.....	1	23
Kansas	5	.....	.....	.....	.....	1	.....	1	.....	.....	.....	1	8	.....	.....	3	.....	3	.....	.....	.....	.....	.....	.....	.....	11
Kentucky	4	.....	2	.....	.....	6	.....	.....	.....	.....	.....	.....	12	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	13
Maryland	2	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	1	6	.....	.....	.....	.....	.....	2	.....	1	.....	.....	.....	3	9
Michigan	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Missouri	6	.....	1	.....	.....	5	.....	.....	.....	.....	.....	.....	12	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	13
Montana	4	.....	.....	1	.....	2	.....	.....	1	.....	.....	.....	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8
New Mexico	3	1	.....	24	.....	.....	.....	.....	.....	.....	.....	.....	28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	28
North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Ohio	21	7	7	.....	.....	11	1	.....	1	1	.....	.....	49	.....	.....	1	.....	1	.....	.....	.....	1	.....	.....	1	51
Oklahoma	2	.....	2	4	.....	1	.....	.....	.....	.....	.....	.....	9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Pennsylvania (anthracite)	147	38	53	32	.....	46	.....	.....	6	.....	1	23	346	13	1	4	.....	18	17	.....	13	4	7	16	57	421
Pennsylvania (bituminous)	89	14	33	4	.....	5	.....	.....	1	.....	.....	3	149	1	.....	1	.....	2	.....	.....	1	.....	1	.....	2	153
Tennessee	5	2	.....	.....	28	2	.....	.....	.....	.....	.....	.....	37	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	37
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Utah	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Washington	.....	1	1	26	.....	1	.....	.....	.....	.....	4	3	36	.....	.....	.....	.....	.....	.....	.....	1	2	.....	.....	3	39
West Virginia	40	8	4	.....	.....	5	.....	.....	.....	.....	.....	3	60	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	4	64
Wyoming	.....	.....	.....	.....	60	.....	.....	.....	.....	.....	.....	.....	60	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	60
Total, 1895	408	95	123	137	88	99	11	1	9	1	7	35	1,014	25	1	20	3	49	25	.....	18	7	11	16	70	1,142

a No inspection, or report not published.

b Cumnock mine explosion, North Carolina.

TABLE 21.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1896, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	16	2	3	.....	.....	2	.....	.....	.....	.....	.....	2	25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	25
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Arkansas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Colorado	14	2	2	.....	49	.....	.....	.....	.....	.....	.....	1	68	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	68
Georgia and North Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Illinois	36	6	7	1	1	11	.....	.....	.....	.....	.....	.....	62	6	.....	1	.....	7	.....	.....	.....	.....	.....	1	1	70
Indiana	9	.....	3	9	.....	2	.....	.....	.....	.....	.....	.....	23	2	.....	3	.....	5	.....	.....	.....	.....	.....	.....	.....	28
Iowa	9	.....	2	.....	2	3	.....	.....	.....	.....	.....	.....	16	2	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	18
Kansas	5	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	.....	10	.....	.....	2	.....	2	.....	.....	.....	.....	.....	.....	.....	12
Kentucky	4	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	6
Maryland	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
Michigan	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Missouri	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	8
Montana	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
New Mexico	3	.....	3	.....	.....	3	.....	.....	.....	.....	.....	.....	9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9
North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Ohio	24	7	5	1	.....	2	.....	1	.....	.....	.....	.....	40	.....	.....	1	.....	1	1	.....	.....	.....	.....	.....	1	43
Oklahoma	6	1	2	4	.....	2	.....	.....	.....	.....	.....	.....	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Pennsylvania (anthracite)	210	36	57	42	.....	35	2	.....	6	.....	1	29	418	11	2	4	1	18	6	....	18	9	12	20	65	501
Pennsylvania (bituminous)	83	31	26	6	13	1	3	2	.....	1	.....	1	167	....	1	4	....	5	2	.....	.....	2	.....	2	6	178
Tennessee	16	2	1	.....	.....	2	.....	.....	.....	.....	.....	.....	21	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	1	22
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Utah	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	2
Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Washington	5	1	.....	.....	.....	1	.....	.....	.....	.....	.....	1	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8
West Virginia	42	5	8	.....	.....	2	.....	.....	.....	.....	.....	4	61	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	3	4	65
Wyoming	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Total, 1896	490	93	119	63	65	72	5	3	6	1	1	44	962	21	3	16	1	41	10	....	19	13	12	27	80	1,083

a No inspection, or report not published.

TABLE 22.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1897, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	17	2	4	4	.....	3	.....	.....	.....	.....	5	3	38	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	39
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Arkansas	1	1	1	.....	14	.....	.....	.....	.....	.....	.....	.....	17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	17
Colorado	15	4	3	.....	12	1	.....	.....	.....	.....	.....	1	36	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	36
Georgia and North Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Illinois	33	11	.....	5	.....	12	1	.....	.....	.....	1	1	64	4	.....	.....	1	5	.....	.....	1	1	1	1	4	72
Indiana	9	.....	1	.....	.....	5	.....	.....	.....	.....	.....	.....	15	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	16
Iowa	12	2	1	.....	.....	2	.....	.....	1	.....	.....	.....	18	3	.....	1	.....	4	.....	.....	.....	1	.....	.....	1	23
Kansas	3	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	5	.....	1	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	6
Kentucky	5	1	2	.....	2	1	.....	.....	.....	.....	.....	.....	11	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	12
Maryland	3	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5
Michigan	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Missouri	7	1	1	.....	.....	1	.....	.....	.....	.....	.....	.....	10	.....	.....	2	.....	2	.....	.....	.....	.....	.....	.....	.....	12
Montana	3	3	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11
New Mexico	2	2	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5
North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Ohio	25	4	3	.....	.....	3	.....	1	.....	.....	.....	.....	36	.....	.....	.....	1	1	.....	.....	.....	1	1	.....	2	39
Oklahoma	6	1	3	2	5	4	.....	.....	1	.....	2	.....	24	1	.....	2	.....	3	.....	.....	.....	1	.....	.....	1	28
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Pennsylvania (anthracite)	146	53	41	35	.....	48	2	.....	.....	.....	13	26	364	5	2	10	.....	17	13	.....	9	.....	5	15	42	422
Pennsylvania (bituminous)	90	21	21	2	.....	4	.....	2	.....	.....	.....	.....	140	1	1	1	.....	3	.....	.....	.....	4	.....	2	6	149
Tennessee	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Utah	1	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Washington	2	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	2	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	7
West Virginia	47	14	7	1	.....	2	.....	.....	.....	.....	.....	.....	71	1	.....	.....	.....	1	2	.....	.....	.....	2	1	5	77
Wyoming	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Total, 1897	437	122	96	49	33	88	3	3	2	.....	21	34	888	16	4	17	2	39	15	.....	11	8	9	20	63	990

a No inspection, or report not published.

TABLE 23.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1898, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.						Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	22	2	9	10	.....	.....	.....	.....	.....	.....	.....	1	44	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	45
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Arkansas	3	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	5
Colorado	13	3	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	20	.....	.....	1	.....	1	2	.....	.....	.....	.....	.....	2	23
Georgia and North Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Illinois	52	7	6	.....	.....	8	2	.....	.....	.....	1	.....	76	6	.....	4	.....	10	1	.....	2	.....	1	.....	4	90
Indiana	13	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	.....	18	.....	1	1	.....	2	.....	.....	.....	1	.....	.....	1	21
Iowa	14	1	3	.....	.....	3	.....	.....	.....	.....	.....	.....	21	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	1	22
Kansas	7	.....	.....	.....	3	5	.....	.....	.....	.....	.....	2	17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	17
Kentucky	3	1	.....	.....	.....	1	.....	.....	.....	1	.....	.....	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
Maryland	3	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
Michigan	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Missouri	6	1	1	.....	.....	1	.....	.....	.....	.....	.....	.....	9	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	10
Montana	1	4	.....	.....	.....	1	.....	.....	.....	.....	.....	1	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7
New Mexico	4	.....	2	.....	.....	1	.....	.....	.....	.....	.....	.....	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	8
North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Ohio	29	5	4	1	.....	3	.....	.....	.....	1	.....	.....	43	1	1	2	.....	4	.....	.....	.....	.....	1	.....	1	48
Oklahoma	4	1	4	4	5	4	.....	1	.....	.....	.....	.....	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	23
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Pennsylvania (anthracite)	145	41	48	34	.....	34	1	1	6	.....	9	28	347	9	9	2	.....	20	8	.....	15	2	4	15	44	411
Pennsylvania (bituminous)	110	21	31	11	.....	5	1	3	.....	.....	3	3	139	1	.....	.....	.....	1	2	.....	3	.....	3	2	10	156
Tennessee	13	1	1	1	.....	1	.....	.....	.....	.....	.....	.....	17	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	2	19
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Utah	2	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3
Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Washington	3	2	4	.....	.....	.....	.....	.....	.....	.....	.....	1	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	11
West Virginia	51	12	13	.....	.....	3	.....	.....	.....	.....	.....	1	80	.....	.....	1	.....	1	4	.....	1	.....	2	2	9	90
Wyoming	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Total, 1898	498	103	133	61	8	75	4	5	6	2	13	37	944	18	11	13	....	41	18	....	22	4	11	22	77	1,062

a No inspection, or report not published.

TABLE 24.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1899, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	13	3	5	5	.....	4	1	.....	.....	.....	.....	.....	36	1	.....	1	.....	2	.....	.....	.....	.....	.....	2	2	40
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Arkansas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Colorado	28	3	6	.....	.....	1	.....	.....	.....	.....	.....	.....	38	.....	.....	1	.....	1	1	.....	.....	.....	.....	.....	1	40
Georgia and North Carolina	.....	.....	.....	b 23	.....	.....	.....	.....	.....	.....	.....	.....	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	23
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Illinois	32	7	7	.....	.....	15	.....	.....	.....	2	.....	.....	63	.....	2	2	1	5	.....	.....	2	.....	2	1	5	73
Indiana	6	.....	2	.....	.....	2	.....	.....	.....	.....	.....	3	13	1	.....	1	1	3	.....	.....	.....	.....	.....	.....	.....	16
Iowa	13	1	1	.....	.....	3	.....	.....	.....	.....	.....	.....	18	5	1	.....	1	7	.....	.....	.....	.....	.....	.....	.....	25
Kansas	8	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	1	14	.....	.....	1	.....	1	.....	.....	1	.....	.....	.....	1	16
Kentucky	4	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	7
Maryland	2	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	5
Michigan	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
Missouri	8	.....	1	.....	2	.....	.....	.....	.....	.....	.....	.....	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11
Montana	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
New Mexico	9	1	2	5	.....	.....	.....	1	.....	.....	.....	.....	18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18
North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Ohio	34	6	4	.....	.....	4	.....	1	.....	.....	.....	.....	49	.....	.....	4	.....	4	.....	.....	.....	.....	2	1	3	56
Oklahoma	7	2	2	4	.....	9	.....	2	.....	.....	.....	.....	26	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	2	28
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Pennsylvania (anthracite)	183	32	57	28	.....	35	4	.....	7	.....	.....	41	387	11	1	4	.....	16	17	.....	13	1	10	17	58	461
Pennsylvania (bituminous)	140	23	38	29	.....	7	.....	5	.....	.....	.....	4	246	3	.....	2	.....	5	1	.....	2	2	.....	2	7	258
Tennessee	13	.....	3	.....	.....	2	.....	.....	.....	.....	.....	.....	18	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	2	20
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Utah	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0
Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Washington	4	4	1	1	31	1	.....	.....	.....	.....	.....	2	44	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	45
West Virginia	51	15	12	3	.....	4	.....	3	.....	.....	.....	1	89	.....	.....	.....	.....	.....	2	.....	.....	1	1	2	6	95
Wyoming	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Total, 1899	560	100	141	98	33	93	5	12	7	2	.....	56	1,107	21	4	16	3	44	24	....	18	4	17	27	90	1,241

a No inspection, or report not published.

b Cumnock mine explosion, North Carolina.

TABLE 25.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1900, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	17	2	4	2	.....	3	.....	.....	.....	.....	.....	9	37	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	37
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Arkansas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Colorado	19	6	2	.....	.....	1	.....	.....	.....	.....	1	.....	29	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	2	31
Georgia and North Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Illinois	48	10	12	.....	.....	18	.....	.....	1	.....	1	1	91	3	1	4	....	8	.....	.....	.....	.....	1	2	3	102
Indiana	11	.....	.....	.....	.....	3	.....	.....	1	.....	.....	.....	15	2	.....	1	....	3	.....	.....	.....	.....	1	.....	1	19
Iowa	17	.....	5	.....	.....	2	.....	.....	.....	.....	.....	.....	24	2	1	1	....	4	1	.....	.....	.....	.....	.....	1	29
Kansas	12	.....	.....	.....	.....	6	.....	.....	.....	.....	.....	1	19	.....	1	1	....	2	.....	.....	.....	.....	.....	.....	.....	21
Kentucky	12	1	1	.....	.....	1	.....	.....	.....	.....	.....	.....	15	1	.....	1	....	2	.....	.....	.....	.....	.....	.....	.....	17
Maryland	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7
Michigan	6	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	8	.....	.....	1	....	1	.....	.....	.....	.....	.....	1	1	10
Missouri	16	.....	1	.....	.....	1	.....	.....	.....	.....	.....	.....	18	.....	.....	1	....	1	.....	.....	.....	.....	.....	.....	.....	19
Montana	1	3	1	.....	.....	2	.....	.....	.....	.....	.....	.....	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7
New Mexico	4	2	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9
North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Ohio	40	5	15	3	.....	3	.....	.....	.....	.....	.....	.....	66	2	.....	.....	.....	2	.....	.....	.....	.....	1	2	3	71
Oklahoma	9	1	2	11	5	4	.....	1	.....	.....	.....	.....	33	.....	2	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	35
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Pennsylvania (anthracite)	133	31	63	38	.....	42	4	.....	.....	.....	3	15	332	8	4	7	....	19	17	.....	9	1	10	23	60	411
Pennsylvania (bituminous)	131	35	41	6	.....	9	1	6	.....	1	1	4	235	8	2	7	....	17	10	.....	.....	.....	2	.....	12	264
Tennessee	8	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Utah	3	.....	.....	4	200	1	.....	.....	.....	.....	.....	1	209	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	209
Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Washington	12	1	1	4	.....	.....	3	.....	.....	.....	5	2	28	.....	.....	.....	.....	.....	.....	.....	1	1	.....	1	3	31
West Virginia	58	7	9	47	.....	19	.....	.....	1	.....	.....	.....	141	.....	.....	.....	.....	.....	7	.....	.....	.....	2	.....	9	150
Wyoming	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Total, 1900	557	105	157	115	205	121	8	7	3	1	11	43	1,333	26	11	24	....	61	35	....	10	2	18	30	95	1,489

a No inspection, or report not published.

TABLE 26.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1901, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	18	6	6	2	.....	6	.....	.....	.....	.....	.....	.....	38	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	2	40
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Arkansas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18	18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18
Colorado	25	3	8	2	8	1	.....	1	1	1	.....	2	52	.....	1	.....	.....	1	.....	.....	.....	2	.....	.....	2	55
Georgia and North Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Illinois	52	8	12	1	.....	19	.....	.....	.....	.....	.....	.....	92	3	2	6	.....	11	1	.....	.....	.....	1	2	4	107
Indiana	11	1	3	.....	.....	4	.....	.....	.....	.....	.....	.....	19	2	.....	3	.....	5	.....	.....	.....	.....	.....	.....	.....	24
Iowa	14	7	2	.....	2	3	.....	.....	.....	.....	.....	.....	28	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	29
Kansas	4	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	1	7	1	1	2	.....	4	.....	.....	.....	.....	.....	.....	.....	11
Kentucky	5	2	5	.....	.....	4	.....	.....	.....	.....	.....	1	17	.....	2	.....	.....	2	.....	.....	.....	1	1	.....	2	21
Maryland	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12
Michigan	2	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
Missouri	10	.....	1	.....	.....	5	.....	.....	.....	.....	.....	.....	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	16
Montana	3	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	2	6	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	7
New Mexico	6	.....	2	.....	3	2	.....	.....	.....	.....	.....	2	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15
North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Ohio	31	6	9	3	.....	8	1	1	.....	.....	.....	1	60	1	.....	1	.....	2	.....	.....	.....	2	.....	.....	2	64
Oklahoma	12	.....	7	8	12	6	.....	1	.....	.....	.....	.....	46	2	.....	8	.....	10	.....	.....	.....	.....	1	.....	1	57
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Pennsylvania (anthracite)	175	39	67	30	.....	54	5	.....	3	.....	3	41	417	18	5	.....	.....	23	16	.....	26	1	11	19	73	513
Pennsylvania (bituminous)	155	34	49	26	1	7	.....	9	4	1	.....	4	290	1	.....	3	.....	4	4	.....	2	.....	1	.....	7	301
Tennessee	16	1	3	.....	20	1	.....	.....	.....	1	.....	1	43	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	43
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Utah	4	3	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8
Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	17	.....	17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	17
Washington	9	5	4	2	.....	2	.....	.....	.....	.....	1	.....	23	2	1	.....	.....	3	1	.....	.....	.....	.....	.....	1	27
West Virginia	70	12	14	11	.....	9	.....	.....	.....	1	1	4	122	1	.....	.....	.....	1	8	.....	.....	.....	1	1	10	133
Wyoming	.....	.....	.....	22	.....	.....	.....	.....	.....	.....	28	.....	50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	50
Total, 1901	622	127	194	107	46	187	6	12	8	4	50	89	1,402	32	12	23	....	67	30	....	29	6	16	24	105	1,574

a No inspection, or report not published.

TABLE 27. NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1903, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	29	.....	9	.....	.....	10	.....	.....	.....	.....	.....	.....	48	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	2	50
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Arkansas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13
Colorado	37	5	2	8	14	3	.....	.....	.....	.....	2	.....	71	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	2	73
Georgia and North Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Illinois	42	12	16	.....	.....	24	.....	.....	.....	.....	.....	1	95	4	1	5	.....	10	.....	.....	.....	.....	1	1	2	107
Indiana	11	.....	3	.....	.....	7	.....	.....	.....	.....	.....	.....	21	.....	.....	2	.....	2	.....	.....	.....	.....	1	.....	1	24
Iowa	15	2	2	.....	22	5	.....	.....	.....	.....	.....	1	47	.....	.....	1	.....	1	.....	.....	.....	.....	1	.....	1	49
Kansas	12	.....	2	.....	.....	7	1	.....	.....	.....	.....	1	23	3	2	.....	.....	5	.....	.....	.....	.....	.....	.....	.....	28
Kentucky	11	1	.....	.....	.....	6	.....	.....	.....	.....	.....	.....	18	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	19
Maryland	3	4	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	11
Michigan	5	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	6	.....	.....	2	.....	2	.....	.....	.....	.....	.....	.....	.....	8
Missouri	5	1	1	.....	.....	1	.....	.....	.....	.....	.....	.....	8	1	.....	1	.....	2	.....	.....	.....	.....	.....	.....	.....	10
Montana	2	1	1	.....	.....	1	.....	.....	.....	.....	.....	7	12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12
New Mexico	7	.....	4	.....	.....	1	.....	.....	.....	.....	2	.....	14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14
North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Ohio	53	5	13	3	.....	9	.....	.....	.....	.....	.....	.....	83	.....	.....	1	.....	1	.....	1	.....	1	.....	.....	2	86
Oklahoma	10	.....	8	4	2	5	.....	1	.....	.....	10	.....	40	.....	.....	.....	.....	.....	1	.....	1	.....	.....	.....	2	42
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Pennsylvania (anthracite)	77	38	44	20	.....	31	.....	.....	2	.....	.....	17	229	8	2	6	.....	16	15	.....	17	4	4	15	55	300
Pennsylvania (bituminous)	200	26	54	126	.....	9	.....	11	1	4	.....	2	433	5	1	8	.....	14	2	.....	2	3	.....	1	8	455
Tennessee	17	1	5	.....	200	3	.....	.....	.....	.....	.....	.....	226	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	226
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Utah	5	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	8
Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Washington	7	5	5	.....	11	2	.....	.....	.....	.....	.....	.....	30	1	1	.....	.....	2	.....	.....	1	.....	.....	1	2	34
West Virginia	61	16	14	23	.....	5	.....	1	.....	.....	.....	.....	120	5	.....	.....	.....	5	6	.....	.....	.....	.....	3	9	134
Wyoming	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	21	21	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	21
Total, 1903	609	117	188	184	249	130	1	13	3	4	14	63	1,575	27	7	26	....	60	28	1	22	10	7	21	89	1,724

a No inspection, or report not published.

TABLE 23.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1903, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	20	2	6	18	.....	3	.....	.....	.....	.....	.....	8	57	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	57
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Arkansas	.....	.....	.....	11	.....	.....	.....	.....	.....	.....	.....	.....	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11
Colorado	26	5	2	.....	1	4	.....	1	.....	.....	.....	1	40	2	.....	.....	.....	2	2	.....	.....	.....	.....	.....	.....	44
Georgia and North Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Illinois	68	7	20	10	.....	40	.....	1	.....	.....	.....	.....	146	2	2	3	1	8	.....	.....	1	.....	1	2	4	158
Indiana	16	2	4	1	.....	19	.....	1	.....	.....	1	1	45	4	.....	2	.....	6	.....	.....	.....	.....	1	.....	1	52
Iowa	16	2	3	.....	.....	3	.....	.....	.....	.....	.....	.....	24	3	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	.....	27
Kansas	19	.....	.....	.....	.....	7	.....	.....	.....	.....	.....	2	28	1	.....	1	.....	2	.....	.....	.....	.....	3	.....	3	33
Kentucky	17	1	.....	.....	.....	5	.....	.....	.....	.....	.....	2	25	1	.....	.....	.....	1	1	.....	.....	.....	.....	.....	1	27
Maryland	4	1	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....	.....	.....	.....	.....	1	.....	.....	.....	1	.....	2	12
Michigan	2	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	4	1	.....	.....	.....	1	.....	.....	.....	2	.....	1	3	8
Missouri	10	.....	1	3	.....	3	.....	.....	.....	.....	.....	.....	17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	17
Montana	4	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5
New Mexico	10	1	1	.....	.....	7	.....	.....	.....	.....	3	.....	22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	22
North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Ohio	75	12	13	4	.....	11	.....	2	.....	1	.....	1	119	1	1	2	.....	4	1	.....	.....	.....	.....	.....	1	124
Oklahoma	10	.....	3	13	4	9	.....	.....	1	.....	.....	.....	40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	2	42
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Pennsylvania (anthracite)	169	40	70	25	.....	58	.....	1	6	.....	4	27	400	22	1	3	.....	26	29	.....	22	2	10	29	92	518
Pennsylvania (bituminous)	217	31	71	23	.....	14	.....	9	1	1	.....	5	372	6	1	2	.....	9	5	.....	2	.....	5	2	14	395
Tennessee	15	.....	2	.....	.....	2	.....	1	.....	.....	.....	.....	20	.....	.....	.....	.....	.....	6	.....	.....	.....	.....	.....	6	26
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Utah	3	2	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	7
Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Washington	10	4	6	.....	.....	2	.....	.....	.....	.....	.....	.....	22	1	.....	.....	.....	1	1	.....	1	.....	.....	.....	2	25
West Virginia	79	20	13	2	3	7	.....	2	1	1	.....	2	130	1	.....	.....	.....	1	12	.....	.....	1	1	2	16	147
Wyoming	.....	.....	.....	169	.....	.....	.....	.....	.....	.....	.....	.....	169	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	169
Total 1903	790	120	221	279	8	196	.....	18	9	3	8	50	1,712	45	5	13	1	64	58	.....	26	5	22	39	150	1,926

a No inspection, or report not published.

TABLE 29. NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1904, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	34	4	7	26	.....	3	.....	.....	.....	.....	.....	9	83	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	83
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Arkansas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Colorado	43	10	10	.....	19	4	.....	1	.....	.....	.....	2	89	1	.....	1	.....	2	1	.....	.....	.....	1	1	3	94
Georgia and North Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Illinois	64	12	17	.....	.....	53	.....	1	.....	.....	.....	2	149	11	.....	6	.....	17	.....	.....	4	1	2	.....	7	173
Indiana	13	.....	6	.....	.....	9	.....	1	.....	.....	.....	.....	29	2	.....	2	.....	4	.....	.....	.....	.....	1	.....	1	34
Iowa	11	2	2	.....	2	1	1	.....	.....	.....	.....	.....	19	.....	2	3	.....	5	.....	.....	.....	.....	.....	1	1	25
Kansas	15	.....	2	.....	.....	11	.....	.....	.....	.....	.....	.....	28	1	.....	2	.....	3	.....	.....	.....	.....	.....	.....	.....	31
Kentucky	6	1	1	.....	5	3	.....	.....	.....	1	.....	.....	17	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	2	3	20
Maryland	7	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	10
Michigan	3	1	.....	.....	.....	1	.....	.....	.....	.....	.....	1	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
Missouri	8	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11
Montana	6	1	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9
New Mexico	5	1	1	.....	.....	1	.....	.....	.....	.....	.....	.....	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8
North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Ohio	64	10	13	.....	.....	13	1	2	.....	4	.....	1	108	4	1	.....	.....	5	2	.....	.....	.....	1	1	4	117
Oklahoma	4	.....	7	3	10	3	.....	.....	.....	.....	.....	.....	27	.....	1	1	.....	2	.....	.....	.....	.....	.....	.....	.....	29
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Pennsylvania (anthracite)	172	66	71	30	.....	69	.....	.....	6	.....	6	40	460	29	9	2	.....	40	33	.....	19	4	10	29	95	595
Pennsylvania (bituminous)	203	32	52	5	179	7	.....	12	.....	2	1	6	499	7	1	8	.....	16	4	.....	3	1	5	5	18	533
Tennessee	19	.....	4	.....	3	2	.....	.....	.....	.....	.....	.....	28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	28
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Utah	4	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	2	8	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	9
Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Washington	5	2	2	.....	17	3	1	.....	.....	.....	.....	.....	30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	31
West Virginia	93	13	16	2	.....	3	.....	3	.....	.....	.....	2	132	2	.....	2	.....	4	10	.....	1	.....	1	1	13	169
Wyoming	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Total, 1904	779	156	215	66	235	190	3	20	6	7	7	65	1,749	57	14	28	.....	99	51	.....	27	6	21	42	147	1,995

a No inspection, or report not published.

TABLE 30.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1905, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	31	3	8	19	112	4	.....	1	.....	.....	.....	9	187	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	187
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Arkansas	5	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	2	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8
Colorado	35	6	8	.....	.....	4	.....	4	.....	.....	.....	.....	57	2	.....	1	.....	3	2	.....	.....	.....	.....	3	5	65
Georgia and North Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Illinois	66	15	19	51	.....	25	.....	2	.....	.....	6	2	186	5	1	5	....	11	.....	.....	2	....	3	1	6	203
Indiana	17	.....	3	2	9	8	.....	.....	.....	.....	.....	1	40	2	.....	3	....	5	.....	.....	.....	.....	1	....	1	46
Iowa	24	1	4	.....	.....	5	.....	.....	.....	.....	.....	1	35	1	.....	.....	....	1	1	.....	.....	.....	.....	.....	1	37
Kansas	23	.....	1	.....	2	13	.....	.....	.....	.....	.....	.....	39	1	.....	.....	....	1	.....	.....	.....	.....	1	....	1	41
Kentucky	19	.....	2	.....	.....	7	.....	.....	.....	.....	.....	.....	28	.....	.....	.....	....	.....	1	.....	.....	.....	2	....	3	31
Maryland	11	2	1	.....	.....	1	.....	.....	.....	.....	.....	.....	15	.....	.....	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	15
Michigan	5	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	3	9	.....	.....	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	9
Missouri	7	1	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	10	1	.....	.....	....	1	.....	.....	.....	.....	.....	.....	.....	11
Montana	5	2	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	8	.....	.....	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	8
New Mexico	5	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	.....	.....	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	7
North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Ohio	71	7	16	1	.....	4	.....	6	.....	4	.....	1	110	1	.....	2	....	3	2	.....	1	4	1	5	13	126
Oklahoma	6	1	3	18	3	8	1	.....	.....	.....	.....	.....	40	.....	.....	.....	....	.....	.....	.....	.....	.....	.....	1	1	41
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Pennsylvania (anthracite)	243	51	82	34	.....	62	5	2	2	.....	.....	28	509	29	1	12	....	42	13	....	34	3	10	33	93	644
Pennsylvania (bituminous)	259	40	66	23	13	18	2	9	2	2	6	3	443	5	1	2	....	8	5	1	1	1	10	6	24	475
Tennessee	18	.....	2	.....	.....	7	.....	1	.....	.....	.....	.....	28	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	29
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Utah	2	1	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	1	.....	.....	.....	1	.....	.....	.....	.....	2	.....	2	7
Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Washington	6	1	3	.....	.....	1	.....	.....	.....	.....	.....	1	12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12
West Virginia	99	7	25	7	38	10	.....	.....	.....	2	.....	8	1	197	.....	.....	2	....	2	6	....	1	....	5	1	13	212
Wyoming	.....	.....	.....	18	.....	.....	.....	.....	.....	.....	.....	.....	18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18
Total, 1905	957	138	247	173	177	181	8	25	6	6	20	52	1,990	46	3	27	....	78	31	1	39	8	35	50	164	2,232

a No inspection, or report not published.

TABLE 31.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1906, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	45	5	12	13	.....	7	.....	6	.....	.....	.....	2	90	.....	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	6	96
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Arkansas	6	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	3	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13
Colorado	37	7	2	34	.....	4	.....	1	.....	.....	.....	.....	85	1	.....	1	.....	2	2	.....	.....	.....	.....	.....	2	89
Georgia and North Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Illinois	66	17	23	3	2	20	.....	.....	.....	.....	.....	1	133	10	2	11	.....	23	.....	.....	.....	1	3	2	6	161
Indiana	19	.....	3	1	.....	4	.....	.....	.....	.....	.....	.....	27	1	.....	2	.....	3	.....	.....	.....	.....	1	.....	1	31
Iowa	14	1	6	.....	.....	5	.....	.....	.....	.....	.....	.....	26	2	.....	.....	.....	2	.....	.....	.....	.....	.....	1	1	29
Kansas	14	1	1	.....	.....	20	.....	.....	.....	.....	.....	.....	36	1	1	.....	.....	2	1	.....	.....	.....	.....	.....	1	39
Kentucky	17	3	2	1	.....	4	.....	1	.....	.....	.....	.....	28	2	1	2	.....	5	4	.....	.....	.....	.....	2	6	39
Maryland	2	1	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	6
Michigan	1	1	.....	.....	.....	.....	.....	1	.....	.....	.....	1	4	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	5
Missouri	12	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	14	1	1	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	16
Montana	2	2	.....	.....	.....	.....	.....	1	.....	.....	8	.....	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13
New Mexico	10	1	2	10	.....	.....	.....	.....	.....	.....	.....	.....	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	23
North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Ohio	75	5	12	3	.....	12	.....	9	2	.....	.....	.....	118	1	1	8	.....	10	3	.....	.....	.....	.....	.....	3	131
Oklahoma	7	.....	4	6	8	17	.....	.....	.....	.....	.....	.....	42	1	.....	.....	.....	1	1	.....	.....	.....	.....	.....	1	44
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Pennsylvania (anthracite)	168	46	67	46	.....	82	1	1	3	.....	.....	23	437	11	2	6	.....	19	30	1	23	1	7	39	101	557
Pennsylvania (bituminous)	269	35	90	10	.....	8	1	26	1	5	.....	2	447	5	2	2	1	10	5	2	4	.....	3	5	19	476
Tennessee	20	.....	3	.....	.....	3	.....	.....	.....	.....	.....	2	28	1	.....	.....	.....	1	2	.....	.....	.....	.....	1	3	32
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Utah	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
Virginia	.....	.....	.....	35	.....	.....	.....	.....	.....	.....	.....	.....	35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	35
Washington	6	1	9	1	.....	.....	.....	1	.....	.....	.....	.....	18	.....	.....	1	.....	1	2	.....	1	.....	.....	.....	3	22
West Virginia	108	12	18	26	66	5	.....	6	.....	1	.....	1	243	7	1	2	.....	10	12	.....	2	.....	2	8	24	277
Wyoming	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Total, 1906	902	138	256	189	76	197	2	53	6	6	8	35	1,868	44	11	36	1	92	62	3	36	2	16	59	176	2,136

a No inspection, or report not published.

TABLE 32.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1907, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	21	3	11	5	57	3	.....	2	.....	.....	.....	52	154	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	154
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Arkansas	7	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	4	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13
Colorado	51	5	9	1	25	2	.....	.....	.....	.....	7	.....	100	2	.....	1	.....	3	1	1	.....	.....	1	1	4	107
Georgia and North Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Illinois	73	20	39	5	.....	31	.....	2	1	.....	.....	3	174	4	3	1	.....	8	.....	.....	3	.....	7	.....	10	192
Indiana	15	1	8	2	.....	18	.....	.....	1	.....	.....	1	46	1	.....	4	.....	5	.....	.....	.....	.....	2	.....	2	53
Iowa	21	7	2	1	1	2	.....	.....	.....	.....	.....	.....	34	1	.....	3	.....	4	.....	.....	.....	1	1	.....	2	40
Kansas	21	.....	1	1	3	6	.....	.....	.....	.....	.....	.....	32	1	.....	2	.....	3	.....	.....	.....	.....	1	1	2	37
Kentucky	11	1	4	.....	.....	7	.....	1	.....	1	.....	.....	25	3	.....	.....	.....	3	1	.....	1	.....	2	.....	4	32
Maryland	2	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3
Michigan	2	.....	1	.....	.....	2	.....	.....	.....	.....	.....	1	6	.....	1	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	7
Missouri	6	.....	1	.....	.....	1	.....	.....	.....	.....	.....	.....	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8
Montana	7	1	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	9	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	2	4	13
New Mexico	12	1	5	.....	11	.....	.....	.....	.....	.....	3	.....	32	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	2	34
North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Ohio	95	3	17	3	.....	4	.....	10	.....	3	.....	5	140	1	.....	.....	.....	1	3	1	2	3	4	.....	13	154
Oklahoma	15	2	2	4	3	12	.....	1	.....	.....	.....	.....	39	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	39
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Pennsylvania (anthracite)	235	44	88	45	.....	87	12	3	9	.....	7	44	574	17	3	7	.....	27	36	2	29	5	13	22	107	708
Pennsylvania (bituminous)	271	37	105	37	239	17	.....	24	1	4	1	7	743	12	2	12	.....	26	11	.....	4	1	3	11	30	799
Tennessee	19	1	3	3	.....	1	.....	2	.....	.....	.....	.....	29	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	30
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Utah	3	.....	1	1	.....	.....	.....	.....	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5
Virginia	.....	.....	.....	11	.....	.....	.....	.....	.....	.....	.....	.....	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11
Washington	10	1	2	10	.....	5	.....	3	.....	.....	.....	1	32	.....	.....	.....	.....	.....	3	.....	1	.....	.....	1	5	37
West Virginia	132	17	37	25	461	20	.....	4	1	1	.....	2	700	4	1	.....	.....	5	12	.....	1	.....	2	16	31	736
Wyoming	7	10	6	.....	2	1	.....	.....	.....	.....	.....	3	29	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	30
Total, 1907	1,036	154	344	154	802	221	13	52	13	9	18	123	2,938	46	10	30	....	86	70	4	44	10	36	54	218	3,242

a No inspection, or report not published.

TABLE 33.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1908, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.								Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	36	3	16	9	.....	12	.....	10	.....	.....	.....	22	108	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	108
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Arkansas	8	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	5	14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14
Colorado	33	5	9	5	.....	3	.....	.....	2	.....	.....	2	59	2	.....	.....	.....	2	1	.....	.....	.....	.....	1	2	63
Georgia and North Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Illinois	61	21	27	3	.....	38	.....	1	.....	1	1	.....	153	6	1	1	.....	8	.....	1	2	.....	8	.....	11	172
Indiana	19	3	6	1	.....	10	.....	1	1	.....	.....	.....	41	1	.....	3	.....	4	.....	.....	.....	.....	.....	.....	.....	45
Iowa	16	3	4	.....	.....	3	.....	.....	.....	.....	.....	.....	26	2	1	2	.....	5	.....	.....	.....	.....	.....	.....	.....	31
Kansas	22	.....	.....	1	3	6	.....	.....	.....	.....	.....	.....	32	1	.....	3	.....	4	.....	.....	1	.....	.....	1	2	38
Kentucky	15	.....	3	.....	9	7	.....	1	.....	.....	.....	.....	35	.....	1	.....	.....	1	2	.....	.....	1	1	.....	4	40
Maryland	.....	3	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	6
Michigan	4	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	5	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	6
Missouri	8	1	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10
Montana	3	4	2	.....	.....	1	.....	.....	.....	.....	9	.....	19	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	2	21
New Mexico	15	1	6	.....	.....	1	.....	.....	.....	.....	.....	.....	23	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	1	24
North Dakota	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
Ohio	71	3	17	2	.....	6	.....	5	.....	1	.....	.....	105	1	1	.....	.....	2	1	.....	.....	.....	1	4	6	113
Oklahoma	3	.....	3	2	2	1	1	.....	.....	.....	29	4	45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	46
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Pennsylvania (anthracite)	235	49	90	55	.....	94	3	1	5	.....	.....	40	572	15	5	4	.....	24	29	1	29	1	8	14	82	678
Pennsylvania (bituminous)	226	36	76	9	154	6	.....	20	.....	4	.....	2	533	4	1	11	.....	16	13	1	2	1	2	3	22	571
Tennessee	26	1	.....	.....	.....	1	.....	4	1	.....	.....	.....	33	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	34
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Utah	2	1	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5
Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Washington	13	1	8	1	.....	.....	.....	1	.....	.....	.....	1	25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	25
West Virginia	121	30	39	1	59	11	.....	10	3	1	.....	2	277	10	.....	.....	.....	10	12	4	2	.....	1	4	23	310
Wyoming	6	3	1	.....	59	1	.....	.....	.....	.....	.....	10	80	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1	81
Total, 1908	945	168	312	89	286	203	4	54	12	7	39	90	2,209	42	10	25	....	77	59	7	36	4	23	30	159	2,445

a No inspection, or report not published.

TABLE 34.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1909, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	61	9	17	6	18	10	2	4	.....	.....	.....	2	129	....	....	....	....	....	....	....	....	....	....	....	....	129
Alaska and California	....	....	....	6	....	....	....	....	....	....	....	....	6	....	....	....	....	....	....	....	....	....	....	....	....	6
Arkansas	9	....	....	....	....	2	....	....	....	....	....	4	15	....	....	....	....	....	....	....	....	....	....	....	....	15
Colorado	56	7	7	12	3	3	.....	1	.....	.....	.....	.....	89	....	1	2	....	3	1	....	1	....	1	2	5	97
Georgia and North Carolina	2	....	....	....	....	....	....	....	....	....	....	....	2	....	....	....	....	....	....	....	....	....	....	....	....	2
Idaho and Nevada	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	(a)
Illinois	53	22	20	45	.....	34	.....	3	2	.....	259	2	440	....	1	6	....	7	....	....	2	1	5	3	11	458
Indiana	23	2	4	.....	6	5	.....	.....	.....	1	.....	1	42	2	1	3	....	6	....	....	....	....	1	....	1	49
Iowa	22	4	5	.....	.....	2	2	1	.....	.....	.....	1	37	1	....	....	....	1	....	....	....	....	1	....	1	39
Kansas	18	.....	1	3	.....	8	.....	.....	1	.....	.....	.....	31	....	....	1	....	1	....	....	....	....	....	....	....	32
Kentucky	20	.....	2	7	.....	2	.....	1	.....	1	.....	.....	33	....	....	....	....	....	....	....	....	....	1	....	1	34
Maryland	11	1	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	13	....	....	....	....	....	5	....	....	....	1	1	7	20
Michigan	5	.....	.....	.....	.....	1	.....	1	.....	.....	.....	1	8	....	....	1	....	1	....	....	....	....	....	....	....	9
Missouri	10	4	.....	.....	.....	4	.....	.....	.....	.....	.....	.....	18	1	....	2	....	3	....	....	....	....	....	....	....	21
Montana	6	2	2	.....	.....	1	.....	.....	.....	.....	.....	.....	11	....	....	....	....	....	....	....	....	....	....	....	....	11
New Mexico	5	4	3	.....	.....	.....	.....	.....	.....	.....	2	.....	14	....	....	....	....	....	....	....	....	....	....	....	....	14
North Dakota	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0
Ohio	66	2	21	1	2	9	.....	2	.....	2	.....	.....	105	1	....	....	....	1	2	....	....	....	....	2	4	110
Oklahoma	6	.....	6	15	4	10	.....	.....	.....	.....	.....	6	47	....	....	....	....	....	1	....	....	....	....	....	1	49
Oregon	....	....	....	....	1	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	1
Pennsylvania (anthracite)	195	59	71	31	.....	69	1	6	6	.....	12	30	480	7	1	2	....	10	23	....	21	3	3	27	77	567
Pennsylvania (bituminous)	250	39	83	9	41	7	.....	22	1	1	3	6	462	7	2	4	....	13	10	....	6	....	3	6	25	500
Tennessee	18	.....	4	.....	.....	3	.....	2	.....	.....	.....	.....	27	....	....	....	....	....	1	....	....	....	....	1	2	29
Texas	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	....	....	....	....	....	....	....	....	....	....	....	....	4
Utah	7	6	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	15	....	....	....	....	....	....	....	....	....	....	....	....	15
Virginia	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11	27	....	....	....	....	....	....	....	....	....	....	....	....	27
Washington	9	4	1	14	.....	3	.....	4	.....	.....	.....	2	37	....	....	....	....	....	1	....	1	....	....	....	2	39
West Virginia	142	30	52	4	67	14	.....	11	.....	.....	.....	3	323	1	....	....	....	1	6	2	....	....	....	4	12	336
Wyoming	11	9	5	.....	.....	4	.....	.....	.....	.....	.....	.....	29	....	....	....	....	....	....	....	....	....	....	1	1	30
Total, 1909	1,025	204	307	153	142	191	5	58	10	5	276	89	2,445	20	6	21	....	47	50	2	31	4	16	47	150	2,642

a No inspection.

TABLE 35.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1910, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.						Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	51	4	20	.....	139	10	.....	6	.....	.....	.....	7	237	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	238
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[c]
Arkansas	10	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	.....	14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14
Colorado	62	11	18	79	131	5	.....	.....	.....	.....	10	2	318	2	.....	.....	.....	2	1	.....	1	.....	.....	1	3	323
Georgia and North Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[c]
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[c]
Illinois	61	13	28	8	.....	9	.....	1	5	.....	.....	.....	125	4	3	6	.....	13	.....	.....	.....	1	3	1	5	143
Indiana	25	.....	6	4	.....	11	.....	1	.....	.....	.....	.....	47	2	.....	2	.....	4	.....	.....	.....	.....	.....	.....	.....	51
Iowa	20	1	3	.....	.....	3	.....	.....	1	.....	.....	1	29	3	.....	.....	.....	3	1	.....	.....	.....	.....	.....	1	33
Kansas	7	.....	1	.....	1	3	.....	.....	.....	.....	.....	.....	12	4	.....	.....	.....	4	.....	.....	.....	.....	.....	1	1	17
Kentucky	20	1	5	.....	40	16	.....	2	.....	.....	.....	1	85	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	86
Maryland	9	2	2	.....	.....	1	.....	.....	.....	.....	.....	1	15	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	1	3	18
Michigan	4	.....	1	.....	.....	1	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
Missouri	8	.....	3	.....	.....	1	.....	.....	.....	.....	.....	2	14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14
Montana	4	3	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12
New Mexico	8	5	1	.....	.....	1	.....	.....	.....	.....	.....	.....	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	16
North Dakota	1	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
Ohio	94	7	16	16	.....	5	.....	7	.....	2	.....	.....	147	1	.....	2	.....	3	5	.....	1	1	2	.....	9	159
Oklahoma	11	.....	3	.....	13	3	.....	.....	.....	.....	.....	1	31	.....	.....	2	3	5	.....	.....	1	.....	.....	2	3	39
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[c]
Pennsylvania (anthracite)	173	80	93	20	.....	82	13	3	1	.....	.....	24	489	11	.....	8	1	20	41	.....	20	1	.....	21	92	601
Pennsylvania (bituminous)	261	47	105	15	.....	10	.....	30	1	2	.....	2	473	9	.....	3	.....	12	11	2	6	5	4	8	36	521
Tennessee	22	.....	3	.....	.....	10	.....	2	.....	.....	.....	.....	37	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	38
Texas	4	.....	1	.....	.....	.....	.....	1	.....	.....	.....	1	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7
Utah	6	4	3	.....	.....	1	.....	.....	.....	.....	.....	1	15	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	3	18
Virginia	35	.....	1	.....	10	.....	.....	3	.....	3	.....	2	54	.....	.....	.....	.....	.....	1	.....	.....	.....	2	.....	3	57
Washington	8	2	4	.....	18	4	.....	3	.....	.....	.....	2	41	.....	.....	.....	.....	.....	1	.....	.....	.....	1	.....	2	43
West Virginia	173	31	55	3	.....	8	.....	20	1	4	.....	1	296	3	.....	11	.....	14	15	.....	1	.....	.....	3	19	329
Wyoming	15	10	3	.....	.....	6	.....	.....	.....	.....	.....	1	35	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	1	36
Total, 1910	1,092	222	380	145	352	195	13	79	9	11	10	49	2,557	39	3	34	4	80	83	2	40	9	12	38	184	2,821

TABLE 36.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1911, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	43	4	14	2	128	5	.....	6	.....	.....	.....	2	204	1	.....	.....	.....	1	.....	.....	.....	.....	2	2	4	209
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[c]
Arkansas	9	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	1	11	.....	.....	.....	1	1	.....	.....	.....	.....	.....	.....	.....	12
Colorado	40	6	10	.....	17	2	2	2	.....	.....	.....	2	81	.....	.....	2	.....	2	1	.....	.....	.....	1	3	5	88
Georgia and North Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[c]
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[c]
Illinois	66	17	41	9	.....	15	1	3	1	.....	.....	1	154	5	.....	7	.....	12	.....	.....	1	1	1	3	6	172
Indiana	17	2	4	1	2	11	.....	2	.....	1	.....	.....	40	3	.....	.....	.....	3	1	.....	.....	.....	1	1	3	46
Iowa	21	.....	12	.....	.....	1	.....	.....	.....	1	.....	.....	35	1	.....	1	1	3	.....	.....	.....	.....	.....	.....	.....	38
Kansas	20	.....	.....	7	3	3	3	1	.....	.....	.....	3	40	1	.....	.....	.....	1	.....	.....	.....	1	.....	.....	1	42
Kentucky	28	.....	5	.....	.....	4	.....	3	.....	1	.....	.....	41	.....	.....	.....	.....	.....	1	.....	1	.....	1	.....	3	44
Maryland	12	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	14	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1	15
Michigan	3	1	.....	.....	.....	.....	.....	2	.....	.....	.....	1	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7
Missouri	6	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1	8
Montana	7	3	2	.....	.....	2	.....	.....	.....	.....	.....	.....	14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14
New Mexico	9	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11
North Dakota	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Ohio	78	8	11	.....	.....	3	.....	3	.....	2	.....	.....	105	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	2	107
Oklahoma	6	.....	5	1	1	9	.....	1	.....	.....	2	.....	25	.....	.....	1	.....	1	.....	.....	.....	.....	.....	1	1	27
Oregon	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Pennsylvania (anthracite)	195	57	92	34	.....	88	14	2	3	.....	72	37	594	17	.....	4	.....	21	26	1	22	1	.....	34	84	699
Pennsylvania (bituminous)	248	60	90	21	8	6	.....	39	2	.....	.....	12	486	3	.....	1	.....	4	12	1	4	3	.....	5	25	515
Tennessee	14	.....	5	.....	84	1	.....	4	.....	.....	.....	.....	108	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	3	111
Texas	5	.....	1	.....	.....	2	.....	.....	.....	.....	.....	.....	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8
Utah	5	5	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	1	13
Virginia	35	.....	18	5	.....	.....	.....	2	.....	.....	.....	.....	60	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	4	8	68
Washington	6	4	8	.....	.....	2	.....	2	.....	.....	1	.....	23	1	.....	.....	.....	1	2	.....	1	.....	.....	.....	3	27
West Virginia	164	28	55	18	23	3	.....	22	1	4	.....	3	321	2	.....	.....	.....	2	10	3	2	.....	2	1	18	341
Wyoming	15	9	4	1	.....	1	.....	.....	.....	.....	.....	1	31	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	32
Total, 1911	1,053	206	382	99	286	160	20	94	7	9	75	63	2,434	34		16	2	52	61	5	31	7	12	54	170	2,656

TABLE 37.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1912, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on surface							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	56	6	15	26	.....	5	.....	8	.....	.....	.....	1	117	2	1	.....	.....	3	.....	.....	.....	.....	3	.....	3	123
Alaska and California	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
Arkansas	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	.....	.....	.....	1	1	.....	.....	.....	.....	.....	.....	.....	6
Colorado	43	9	13	15	2	1	.....	6	1	.....	.....	3	93	.....	.....	1	.....	1	1	.....	.....	.....	1	.....	2	96
Georgia and North Carolina	1	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Illinois	65	19	41	3	.....	11	.....	2	2	1	.....	.....	144	6	1	5	.....	12	1	.....	.....	1	3	2	7	163
Indiana	20	.....	8	2	2	2	.....	.....	.....	.....	.....	.....	34	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	35
Iowa	9	2	3	.....	2	3	.....	.....	.....	.....	.....	.....	19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19
Kansas	13	.....	2	.....	1	11	.....	1	.....	.....	.....	.....	28	.....	.....	1	.....	1	.....	.....	.....	.....	1	.....	1	30
Kentucky	19	1	5	5	5	1	.....	5	.....	1	.....	.....	42	.....	.....	2	.....	2	3	.....	.....	.....	1	3	7	51
Maryland	8	4	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	15
Michigan	4	.....	.....	.....	.....	.....	.....	1	.....	1	.....	.....	6	.....	1	.....	.....	1	.....	.....	.....	.....	1	.....	1	8
Missouri	7	2	2	2	1	.....	.....	2	.....	.....	.....	.....	16	1	.....	2	.....	3	.....	.....	.....	.....	.....	.....	.....	19
Montana	2	1	2	.....	.....	2	.....	.....	.....	.....	.....	.....	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7
New Mexico	8	2	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	16
North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ohio	91	8	16	2	.....	5	.....	2	.....	1	.....	4	129	1	.....	1	.....	2	.....	.....	2	.....	1	1	4	135
Oklahoma	6	1	3	75	2	1	.....	.....	.....	.....	11	.....	99	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	99
Oregon	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Pennsylvania (anthracite)	166	77	79	35	.....	77	5	5	2	.....	.....	30	476	18	2	2	.....	22	41	2	22	2	.....	36	103	601
Pennsylvania (bituminous)	206	43	106	1	.....	8	.....	18	1	.....	.....	17	400	4	.....	3	.....	7	16	2	7	2	.....	12	39	446
Tennessee	13	1	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	2	18
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	1	.....	.....	.....	.....	.....	.....	1
Utah	5	9	2	.....	.....	.....	1	1	.....	.....	.....	.....	18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	19
Virginia	33	.....	9	10	.....	10	.....	4	.....	1	.....	.....	67	1	.....	.....	.....	1	3	1	.....	.....	1	2	7	75
Washington	3	3	3	.....	.....	1	.....	3	.....	.....	.....	.....	13	.....	.....	.....	1	1	.....	.....	.....	.....	.....	.....	.....	14
West Virginia	176	18	45	8	83	8	.....	21	.....	2	.....	.....	361	.....	.....	2	.....	2	11	3	2	.....	2	.....	18	381
Wyoming	16	5	5	.....	7	.....	.....	1	.....	.....	.....	.....	34	.....	.....	1	.....	1	1	.....	.....	.....	.....	.....	1	36
Total, 1912	975	211	371	185	105	147	6	80	6	7	11	55	2,159	33	5	20	3	61	78	8	33	5	14	61	199	2,419

TABLE 38.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1913, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on the surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	61	7	19	3	13	2	11	5	.....	.....	.....	2	123	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	124
Alaska and California	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	2
Arkansas	5	1	1	.....	2	1	.....	.....	.....	.....	1	.....	11	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	12
Colorado	46	1	7	.....	37	4	3	2	1	3	.....	1	105	.....	.....	.....	.....	.....	1	.....	1	.....	.....	1	3	108
Georgia and North Carolina	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Illinois	59	21	38	8	.....	11	1	8	1	.....	1	5	153	2	1	1	.....	4	.....	.....	1	1	2	3	7	164
Indiana	24	5	8	7	8	4	.....	1	1	.....	.....	a 1	59	2	.....	2	1	5	1	.....	.....	.....	.....	1	2	66
Iowa	18	.....	6	.....	1	1	.....	.....	.....	.....	.....	.....	26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	26
Kansas	17	.....	.....	1	2	4	.....	.....	1	.....	.....	.....	25	.....	.....	2	.....	2	.....	.....	.....	.....	.....	1	1	28
Kentucky	24	1	1	.....	.....	1	b 5	4	.....	2	.....	4	42	2	.....	.....	1	3	1	.....	.....	.....	.....	2	3	48
Maryland	6	.....	3	.....	.....	2	.....	.....	.....	.....	.....	1	12	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1	13
Michigan	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	3
Missouri	8	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10
Montana	9	4	2	.....	.....	2	.....	.....	.....	.....	.....	.....	17	.....	.....	.....	1	1	.....	.....	.....	.....	2	.....	2	20
New Mexico	3	1	2	.....	261	2	2	.....	.....	.....	.....	1	272	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	272
North Dakota	3	.....	2	.....	.....	1	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
Ohio	90	3	32	15	.....	6	.....	9	.....	2	.....	2	159	3	.....	1	.....	4	.....	.....	.....	.....	1	1	2	165
Oklahoma	7	.....	6	2	1	4	.....	2	.....	.....	.....	.....	22	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	23
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pennsylvania (anthracite)	192	65	85	50	.....	75	11	1	4	4	.....	36	523	30	.....	.....	.....	30	35	1	15	.....	.....	14	65	618
Pennsylvania (bituminous)	257	56	102	.....	97	4	.....	23	.....	6	.....	9	554	7	.....	.....	.....	7	26	5	6	.....	.....	11	48	609
Tennessee	20	5	6	.....	.....	.....	.....	1	.....	.....	1	1	34	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	35
Texas	2	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
Utah	3	.....	6	.....	.....	1	.....	.....	.....	.....	.....	1	11	1	.....	.....	.....	1	3	1	.....	.....	1	.....	5	17
Virginia	11	1	4	.....	.....	.....	.....	4	.....	.....	1	3	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	24
Washington	7	.....	4	5	1	2	.....	1	.....	.....	.....	1	21	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	22
West Virginia	170	30	86	.....	.....	8	.....	17	.....	6	.....	2	319	1	.....	1	.....	2	10	1	2	.....	.....	3	16	337
Wyoming	13	2	4	.....	.....	1	.....	2	1	1	.....	.....	24	.....	.....	.....	.....	.....	1	.....	.....	.....	1	.....	2	26
Total, 1913	1,060	204	494	91	423	138	33	60	9	24	4	72	2,562	50	1	9	2	62	78	8	26	1	8	40	161	2,785

a Fatality in mine employing less than 10 men.

b Suffocated by entering an abandoned mine.

TABLE 30.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1914, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on the surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosion or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
Alabama	53	.....	24	37	.....	1	.....	11	.....	1	.....	.....	127	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1	128
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0
Arkansas	3	.....	3	2	1	1	.....	.....	.....	.....	.....	.....	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	11
Colorado	40	2	13	1	.....	4	.....	6	.....	2	.....	4	72	.....	.....	1	.....	1	.....	.....	.....	.....	.....	2	2	75
Georgia and North Carolina	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Illinois	49	20	38	55	.....	9	.....	2	.....	2	1	.....	176	4	2	1	1	8	.....	.....	2	.....	3	4	9	193
Indiana	18	3	4	2	1	6	.....	2	1	1	.....	2	40	.....	.....	2	.....	2	.....	.....	.....	.....	2	.....	2	44
Iowa	17	1	5	.....	5	3	1	.....	.....	.....	.....	.....	32	3	.....	2	.....	5	.....	.....	.....	.....	.....	.....	.....	37
Kansas	14	.....	.....	8	1	.....	.....	1	.....	.....	.....	1	25	6	1	.....	.....	7	.....	.....	1	.....	.....	.....	1	33
Kentucky	30	.....	13	.....	1	6	.....	2	.....	1	.....	.....	53	2	.....	.....	.....	2	2	1	1	.....	1	1	6	61
Maryland	15	1	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	17	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	18
Michigan	1	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
Missouri	12	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	14	.....	.....	5	.....	5	.....	.....	.....	.....	.....	.....	.....	19
Montana	6	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	8
New Mexico	14	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	16	1	.....	.....	.....	1	.....	.....	.....	.....	.....	1	1	18
North Dakota	1	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3
Ohio	44	1	10	1	.....	2	.....	1	.....	2	.....	1	62	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	2	64
Oklahoma	20	.....	3	1	1	2	.....	3	.....	.....	.....	1	31	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	31
Oregon	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Pennsylvania (anthracite)	166	62	76	44	.....	90	8	3	2	1	.....	34	486	47	.....	.....	.....	47	30	1	13	.....	.....	18	62	595
Pennsylvania (bituminous)	189	44	89	3	.....	7	5	25	1	3	.....	10	376	3	.....	.....	.....	3	13	2	3	1	.....	4	23	402
Tennessee	19	2	1	1	.....	1	.....	.....	.....	.....	.....	.....	24	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	2	26
Texas	4	2	1	1	.....	1	.....	.....	.....	.....	.....	1	10	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	11
Utah	9	.....	6	.....	.....	.....	.....	1	.....	1	.....	.....	17	.....	.....	.....	.....	.....	.....	.....	2	2	1	.....	5	22
Virginia	12	1	1	.....	.....	.....	.....	1	.....	.....	.....	.....	15	1	1	.....	.....	2	5	5	.....	.....	.....	.....	10	27
Washington	6	2	3	1	.....	3	.....	1	.....	.....	.....	.....	16	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	17
West Virginia	220	.....	73	182	.....	5	.....	29	2	5	5	3	534	2	1	1	.....	4	9	2	1	1	4	11	28	566
Wyoming	22	5	9	.....	.....	4	.....	1	1	.....	1	.....	43	.....	.....	.....	.....	.....	5	.....	2	1	.....	.....	8	51
Total, 1914	985	146	380	332	17	146	14	89	7	20	7	57	2,200	70	5	12	1	88	68	11	26	5	13	43	166	2,454

CUSTOMARY BASIS FOR COMPUTING FATALITY RATES.

The customary basis for computing fatality rates is on the number of men employed in the industry. This basis is faulty to the extent that under existing conditions it is not possible to obtain the exact number of men at work, for the reason that all of the men do not work throughout the year. There are always a number of men who work a few days at one property and either quit or are discharged and go to other mines. The actual number of men on the pay roll is, therefore, much higher than the number of men really at work in the mines, and unfortunately it is the former figure that the operators too frequently report. It is also imperfect in that no distinction is made concerning the number of working hours per day. In some States the 8-hour day prevails, whereas in others 9 or 10 hours constitute a legal day.

The comparison of fatality rates on a percentage basis is far from being correct. For example, there may be 1,000 fatalities due to various causes in a certain group of mines, 50 per cent of which may be attributed to some one cause, as falls of rock, and 25 per cent to some serious gas and dust explosion. The difficulty with the percentage basis is that the number killed in a large disaster enters into the total number of men killed in that particular group of mines. When the total is thus abnormally increased the effect is to decrease the percentage rate of each of the other causes to balance the excess which is due to the one large disaster. In the assumed case above cited, in which 25 per cent of the fatalities were due to a gas and dust explosion, the elimination of the number killed (250) in this particular disaster from the total would leave only 750 fatalities, and the percentage of fatalities due to falls of rock, which in the first case was 50 per cent, would be increased to 66⅔ per cent, although the actual number, 500, killed by falls of rock remains the same, and roof conditions have not changed.

The tonnage basis for comparison is also open to some criticism in that mining conditions are not the same in all mines or States. One mine may be in a coal bed 7 or 8 feet thick, and another mine in a bed 2 feet 6 inches thick. It is evident that a miner working in thick coal can produce more tons per year than a miner working in thin coal. The first mine would show a lower fatality rate on the tonnage basis, although in each mine the men were exposed to the mining risk the same number of days per year, indicating that the thicker coal bed is safer than the thinner bed. As a matter of fact the thinner coal bed is the safer of the two, as shown by the low fatality rate in Iowa as compared with the rates of Illinois and Indiana and some other States.

For certain purposes, each method has its champion, and in order to meet the requirements of all, the three bases have been used throughout this bulletin. But for true hazard rates, that one serves

best which takes into account the number of men and the time they are engaged in a hazardous occupation. This necessitates reducing all labor to a standard year of a certain number of hours, 2,000 or 3,000 as the case may be, representing a definite number of days (shifts) of 8 or 10 hours each. The ideal method would be for the operators to report the actual number of hours' labor for which wages were paid during the year. This figure divided by 2,000 would give the number of 2,000-hour employees; that is, the actual number of men who were exposed to the mining hazard the full 2,000-hour period. They would, therefore, all be on the same time basis. The total number of hours divided by 3,000 would place the employees on a 300 (10-hour) day year, but inasmuch as coal mines are operated less than 2,000 hours per year, the shorter year is more nearly in keeping with actual conditions, and therefore preferable. Figures approximating this condition are given in Tables 40 and 41.

TABLE 40.—FATALITY RATES BASED ON THE NUMBER OF 2,000-HOUR WORKERS AS COMPARED WITH THE RATE BASED ON THE NUMBER OF MEN REPORTED AS EMPLOYED, 1903–1913, INCLUSIVE, EXCEPT 1909.

[See Plate III.]

State.	Days worked per year (10-hour).	Actual number of men employed (10-year period).	Number of 2,000-hour workers.	Fatalities for 10-year period.			Fatalities per 1,000 men.					
							Exceptional.		Common.		Total.	
				Exceptional accidents.	Common accidents.	Total.	Actual employees.	2,000-hour workers.	Actual employees.	2,000-hour workers.	Actual employees.	2,000-hour workers.
Alabama	225.5	211,382	238,316	474	905	1,379	2.24	1.98	4.28	3.80	6.52	5.78
Arkansas	131.4	[a] 39,003	24,611	.....	92	92	.....	.....	2.36	3.74	2.36	3.74
Colorado	217.2	123,713	134,371	367	710	1,077	2.97	2.73	5.74	5.29	8.71	8.02
Illinois	156.7	664,866	521,053	116	1,585	1,701	.17	.22	2.38	3.04	2.55	3.26
Indiana	148.7	209,054	155,453	16	443	459	.08	.10	2.12	2.85	2.20	2.95
Iowa	170.4	157,415	134,128	.....	305	305	.....	.....	1.94	2.27	1.94	2.27
Kansas	156.4	124,576	97,430	12	324	336	.10	.12	2.60	3.33	2.70	3.45
Kentucky	188.5	187,589	176,793	79	339	418	.42	.45	1.81	1.91	2.23	2.36
Maryland	242.8	[a] 47,611	57,957	.....	104	104	.....	.....	2.18	1.79	2.18	1.79
Michigan	162.0	35,454	28,725	.....	65	65	.....	.....	1.83	2.26	1.83	2.26
Missouri	153.9	95,056	73,154	.....	124	124	.....	.....	1.30	1.70	1.30	1.70
Montana	193.0	29,887	28,840	17	105	122	.57	.59	3.51	3.64	4.08	4.23
New Mexico	246.3	29,776	36,669	289	144	433	9.70	7.88	4.84	3.93	14.54	11.81
North Dakota	197.4	[b] 3,188	3,244	.....	13	13	.....	.....	4.08	4.01	4.08	4.01
Ohio	149.5	452,089	337,891	35	1,296	1,331	.07	.10	2.87	3.84	2.94	3.94
Oklahoma	140.6	84,418	63,009	150	279	429	1.77	2.38	3.31	4.46	5.08	6.81
Pennsylvania (anthracite)	198.5	1,668,725	1,655,961	240	5,979	6,219	.14	.14	3.59	3.62	3.73	3.76
Pennsylvania (bituminous)	203.4	1,573,200	1,599,843	838	4,502	5,340	.53	.52	2.86	2.82	3.39	3.34
Tennessee	210.0	112,247	117,869	84	297	381	.75	.71	2.65	2.52	3.40	3.23
Texas	210.1	[c] 19,405	20,043	.....	21	21	.....	.....	1.08	1.05	1.08	1.05
Utah	210.9	25,084	26,451	.....	104	104	.....	.....	4.15	3.93	4.15	3.93
Virginia	244.7	[c] 33,211	42,553	26	198	224	.78	.61	5.96	4.65	6.74	5.26
Washington	202.3	55,641	56,290	66	192	258	1.19	1.17	3.45	3.41	4.64	4.58
West Virginia	213.2	562,525	620,895	839	2,380	3,219	1.44	1.35	4.09	3.83	5.53	5.18
Wyoming	213.7	[b] 39,171	36,982	65	146	211	1.66	1.76	3.72	3.95	5.38	5.71
Total and average	190.9	6,604,289	6,288,531	3,713	20,652	24,365	.56	.59	3.13	3.28	3.69	3.87

[a] Employees and fatalities for 8 years only.
[b] Employees and fatalities for 5 years only.
[c] Employees and fatalities for 4 years only.

TABLE 41.—FATALITY RATES PER 1,000 MEN, BY STATES, COMPARED ON A UNIFORM BASIS OF 2,000-HOUR WORKERS.[a]

State.	1903	1904	1905	1906	1907	1908	[b]1909	1910	1911	1912	1913	Average.
Alabama	2.47	4.58	8.91	4.15	6.23	5.30	.....	8.82	8.77	4.62	4.07	5.78
Arkansas	.....	.....	2.09	4.58	3.35	4.52	.....	4.88	4.21	2.09	3.71	3.74
Colorado	3.98	9.40	4.99	6.49	6.28	4.43	.....	18.78	6.48	7.13	9.74	8.02
Illinois	3.40	3.70	4.33	3.37	3.32	3.40	.....	3.06	3.02	2.08	2.72	3.26
Indiana	3.86	2.44	2.99	2.10	3.15	3.51	.....	2.53	3.01	2.21	3.89	2.95
Iowa	2.08	1.87	2.89	2.11	2.78	2.24	.....	2.26	2.76	1.54	2.11	2.27
Kansas	3.47	2.96	4.01	4.04	3.26	3.73	.....	2.22	4.63	3.17	2.84	3.45
Kentucky	1.98	1.56	2.30	2.64	1.97	2.73	.....	4.19	1.98	2.26	1.86	2.36
Maryland	1.94	1.59	2.02	.75	.....	.....	.....	2.30	2.05	1.89	1.88	1.79
Michigan	3.04	2.24	3.23	1.82	1.88	1.71	.....	1.98	2.47	3.51	1.21	2.28
Missouri	2.06	1.31	1.56	2.23	1.10	1.03	.....	2.32	1.14	2.36	1.28	1.70
Montana	2.08	3.38	3.67	5.53	4.43	7.38	.....	3.24	4.12	2.31	6.00	4.23
New Mexico	9.77	3.85	2.87	9.32	8.65	7.16	.....	3.18	2.00	2.99	49.26	11.81
North Dakota	.....	.....	.....	.....	.....	7.55	.....	3.83	1.22	.....	8.78	4.01
Ohio	3.78	3.82	4.11	4.30	4.11	3.68	.....	4.18	3.28	3.67	4.37	3.94
Oklahoma	5.44	4.27	7.04	7.97	5.33	7.67	.....	7.80	4.92	16.01	3.21	6.81
Pennsylvania (anthracite)	3.71	4.24	4.02	3.91	4.28	4.33	.....	3.44	3.63	3.32	3.04	3.76
Pennsylvania (bituminous)	2.96	4.66	3.25	3.15	4.45	3.97	.....	2.89	2.99	2.48	3.07	3.24
Tennessee	2.46	2.69	2.37	2.62	2.35	3.01	.....	3.06	9.23	1.60	2.78	3.22
Texas	.....	.....	.....	.....	.....	.....	.....	1.62	1.63	.39	.71	1.05
Utah	3.29	5.56	5.20	2.21	2.18	2.06	.....	5.67	3.94	5.01	3.73	3.83
Virginia	.....	.....	.....	.....	.....	.....	.....	6.67	6.53	6.93	1.88	5.26
Washington	3.92	5.87	2.67	4.52	5.66	5.54	.....	6.63	4.03	2.79	3.65	4.58
West Virginia	3.55	3.33	4.43	5.16	11.40	6.09	.....	4.35	4.77	4.34	4.07	5.18
Wyoming	.....	.....	.....	.....	.....	13.46	.....	4.55	4.18	4.09	3.36	5.71
Average	3.31	3.97	3.91	3.72	4.87	4.28	.....	4.03	3.78	3.32	3.58	3.87

[a] For details from which this table is derived see special tables under each individual State.
[b] Complete data not available.

COMPARISON OF FATALITY RATES ON A UNIFORM TIME BASIS.

In the comparison of mine accidents the time element should be taken into consideration. In other words, the length of time that a man is exposed to the mining risk is an important factor in arriving at the true risk in the mining industry, and especially so when one State is compared with another. With this end in view, Tables 40 and 41 are based upon a uniform period of two hundred 10-hour shifts.

The tables under the various States show the number of 8, 9, and 10 hour men over a period of 10 years. There are also a number of men unclassified, but for this comparative study they have been taken as 9-hour men. Concerning the actual number of working hours E. W. Parker says: [a]

It should be remembered, however, that when the length of the working day is stated, reference is made to the number of hours the mines are supposed to have been in operation and not to the number of hours worked by the miners. In both the anthracite and bituminous fields practically all the coal is mined by contract at an agreed rate per ton or other basis of payment. The miner is an independent contractor and is not obliged to put in a certain number of hours at his working place. The figures in the following table really indicate the number of hours the men were given an opportunity to work and do not mean that all the employees worked 8, 9, or 10 hours, as the case might be.

[a] Mineral Resources of the United States for the calendar year 1913, U. S. Geol. Survey, 1915, p. 754.

Since the settlement of the anthracite strike of 1902 the mines in that region have been operated on a 9-hour basis, with the exception of engineers and pumpmen, who work 8 hours, and of the miners, who work by contract.

While these figures as previously stated, may not be strictly exact, it is certain that in an 8-hour State there will not be many 10-hour men. Yet it is believed that in a 10-hour State the majority of the men will work about two hours longer than in an 8-hour State. Inasmuch as these labor statistics were all collected by one bureau, the United States Geological Survey, they are all on the same basis, and for comparative purposes should serve nearly as well as exact figures. They are the only figures available by which it is possible to attempt a study of mine accidents in relation to the length of exposure to the many dangers attending the industry.

Exact data along these lines are desirable; and it is hoped that mining companies, State officials, and industrial-accident commissions will realize the importance of arriving at a true risk and cooperate in obtaining such information as may reveal the true accident hazard in the mining industry.

The State tables (see list of States in Tables 40 and 41) cover a 10-year period from 1903 to 1913 inclusive, except for the year 1909, for which complete data are lacking. This information is available for 24 States, and the varying hours, number of employees, and the working days have been given proper weight, with the result that the total number of working hours in each State has been computed for the 10-year period, and their sum gives the total number of working hours in all the States. This divided by the number of men reported working gives an average year of 1,909 hours for the United States as a unit. The working hours in each State divided by 2,000 gives the equivalent of 2,000-hour workers, upon which fatality rates may be based. The number of calculated 2,000-hour workers is given in parallel with a column showing the number of employees as reported.

Table 40 shows the number of working hours per year in each State as varying from 1,314 in Arkansas to 2,447 in Virginia. The Pennsylvania anthracite field works 1,985 and the Pennsylvania bituminous 2,034 hours per year. In view of the fact that this range varies from a few hours below to a few hours above 2,000, and that the average for the United States is 1,909, a 2,000-hour year has been adopted for calculations in the accompanying tables. It is more nearly in keeping with actual mining conditions to base the calculations on a 2,000-hour year than it would be to base them on a 3,000-hour year, as is frequently done in factories, metallurgical works, and in other industrial plants. Anyone desiring a 3,000-hour basis may obtain it by adding 50 per cent to all of the rates given in Tables 40 and 41.

Table 40 gives the number of fatalities that are due to *exceptional accidents* and those due to *common accidents*, the exceptional acci-

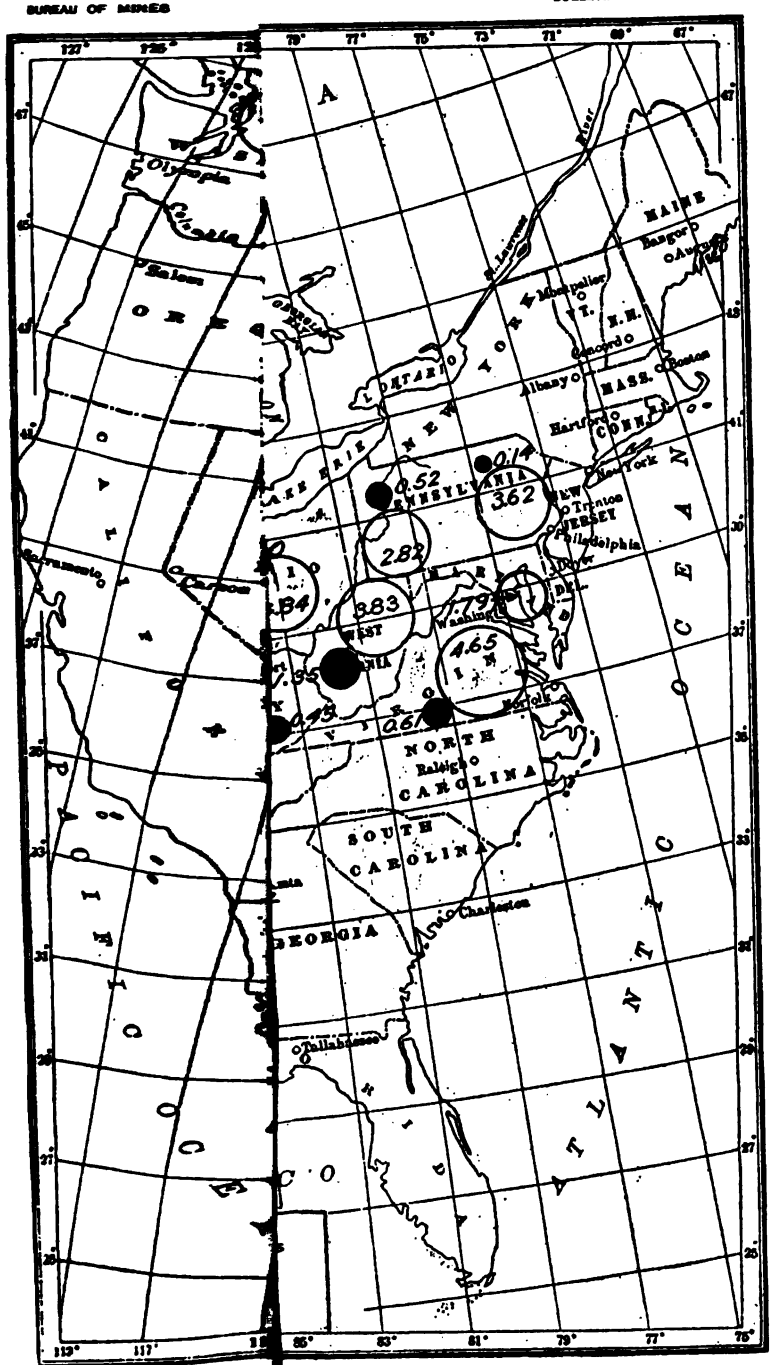
dent being one in which five or more men are killed at a time, and the common accident one that occurs in every-day mining operations, wherein usually one or two men but not more than four, may be involved at a time.

The length of time during which miners are exposed to the hazards of the industry varies in different States, due to both commercial requirements and labor organizations. The number of hours a day is largely regulated by labor organizations and State laws, and the number of days worked a year is regulated more or less by commercial conditions. When the demand for coal is slight the output is curtailed by working part of the time, or by closing the mines entirely for several weeks to await better market conditions.

The actual average number of days that the mines are operated each year is given in the State tables. The tables show that this number varies from year to year for the same State. For example, in 1906 Colorado averaged 268 working days, while in 1911 the mines were operated 207 days. Arkansas in 1903 operated 223 days, and in 1910 only 128 days. Ohio varied from 161 days in 1908 to 206 days in 1913. With such wide differences in the number of days that the mines are in operation, it is evident that the hazards in each State are not the same.

Another reason why they are not comparable is that the number of hours worked per day is not the same in each State. For example, Ohio, Indiana, Illinois, Iowa, and a number of other States are on an 8-hour basis with but few 9-hour and 10-hour men. On the contrary, in Alabama, Kentucky, West Virginia, Maryland, and a few others, the majority of the men work 9 hours and many of them 10 hours, as shown in the State tables.

It is not a fair classification to place the fatality rate of an 8-hour State on an equal basis with that of a 10-hour State, when the men of the latter State are exposed to the mining risk 25 per cent longer. Every hour adds 12½ per cent to the hazard, as compared with an 8-hour day. As an example of unfair comparison Ohio and Montana may be cited. The fatality rate for Ohio (Table 40) is 2.94 per 1,000, based on the actual number of men working, regardless of the time element, and the rate for Montana is 4.08 per 1,000. When the rates are reduced to a common basis of 2,000 working hours a year, the Ohio rate becomes 3.94 and the Montana rate 4.23, so that the difference on the 2,000-hour basis is 0.29, as compared with 1.14 per 1,000 on the customary basis. The same comparison may be made for other States. In Virginia many of the mines are worked 10 hours a day and from 200 to 280 days per year, thus increasing the time of exposure and giving on the customary basis a fatality rate of 6.74, which, if reduced to the 2,000-hour year, becomes 5.26, comparing favorably with West Virginia at 5.18 per 1,000.



COAL-MINE FATA[illegible]EPRESENT RATE IN COMMON ACCIDENTS. SOLID

Table 41 shows the fatality rate by States and calendar years, for a 10-year period wherein all rates are based on the number of 2,000-hour workers. The detail figures from which this table is derived will be found in the special tables in Part II under each individual State.

Plate III shows comparative fatality rates at the coal mines of the States in which coal is produced, based on a uniform period of 2,000 working hours per year, thus placing all of the States on a comparable basis, as indicated in Table 40. The circles represent the fatality rate per 1,000 men employed, wherein only the "common accidents" are considered. The solid circles represent the fatality rate per 1,000 men employed, for the "exceptional accidents." This chart represents the average of each State for a 10-year period, except where noted in Table 40. The common-accident hazard varies somewhat from one State to another, yet the difference is much smaller than usually shown where the time element is not taken into consideration.

PRINCIPAL CAUSES OF MINE ACCIDENTS.

COAL-MINE DISASTERS.

A summary of the coal-mine accidents in the United States in which 5 or more men were killed at one time, together with the number of such accidents, is given in Table 42. This table shows that since 1839 there have been 297 mine disasters in which 5 or more men were killed at one time, representing 7,590 fatalities. Of this number, 6,126 were killed by gas and dust explosions, 199 of the disasters falling into this class. There were 30 mine fires, claiming 809 victims. There were 144 accidents in which 5 to 9 men were killed at one time, representing 911 fatalities. Although this group represents the greatest number of accidents, the largest number of men killed is in that group in which from 100 to 199 fatalities resulted from a single disaster. There were 12 such disasters, resulting in 1,715 fatalities. Details relating to individual accidents classified in this table are given in Table 44.

TABLE 42.—COAL-MINE ACCIDENTS IN THE UNITED STATES IN WHICH FIVE OR MORE MEN WERE KILLED, CLASSIFIED ACCORDING TO CAUSE AND NUMBER KILLED.

Number of deaths resulting from accidents.	Gas and coal-dust explosions.		Mine fires.[a]		Explosives.		Inrush of water.		Falls of roof and coal.		Mine cars and locomotives.		Shaft accidents.		Other causes.		Total.	
	Number of separate accidents.	Total number killed.	Number of separate accidents.	Total number killed.	Number of separate accidents.	Total number killed.	Number of separate accidents.	Total number killed.	Number of separate accidents.	Total number killed.	Number of separate accidents.	Total number killed.	Number of separate accidents.	Total number killed.	Number of separate accidents.	Total number killed.	Number of separate accidents.	Total number killed.
5 to 9	79	506	19	124	18	111	1	6	4	24	5	28	11	71	7	41	144	911
10 to 24	68	1,119	4	50	5	61	4	51	3	36	2	20	4	43	1	10	91	1,390
25 to 49	20	773	4	125	.....	.....	1	26	.....	.....	.....	.....	.....	.....	.....	.....	25	924
50 to 99	17	1,169	1	72	.....	.....	1	69	1	58	.....	.....	.....	.....	.....	.....	20	1,368
100 to 199	11	1,536	1	179	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	1,715
200 to 299	3	702	1	259	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	961
300 and more	1	361	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	361
Total	199	6,126	30	809	23	172	7	153	8	118	7	48	15	114	8	51	297	7,590

[a] Does not include mine fires in which an explosion of gas or coal dust was the principal destructive agent, as follows: Hanna mine No. 1, Hanna, Wyo., 169 killed, June 30, 1903; Zeigler mine, Zeigler, Ill., 26 killed, Jan. 10, 1908; Victor American mine No. 3, Delagua, Colo., 79 killed, Nov. 8, 1910.

TABLE 43.—FATALITIES IN AND ABOUT THE COAL MINES OF THE UNITED STATES CLASSIFIED ACCORDING TO COMMON AND EXCEPTIONAL ACCIDENTS.[a]

[See fig. 4.]

Year.	Number killed.			Number killed per 1,000 employed.		
	In exceptional accidents.	In common accidents.	Total.	In exceptional accidents.	In common accidents.	Total.
1870	21	190	211	0.59	5.34	5.93
1871	25	185	210	.67	4.93	5.60
1872	.....	223	223	.....	4.98	4.98
1873	10	253	263	.21	5.25	5.46
1874	.....	260	260	.....	3.87	3.87
1875	.....	260	260	.....	3.06	3.06
1876	.....	242	242	.....	2.83	2.83
1877	14	211	225	.17	2.60	2.77
1878	5	230	235	.06	2.56	2.62
1879	11	306	317	.12	3.18	3.30
1880	5	269	274	.04	2.17	2.21
1881	.....	340	340	.....	2.93	2.93
1882	5	443	448	.03	2.72	2.75
1883	79	463	542	.49	2.85	3.34
1884	40	498	538	.21	2.59	2.80
1885	52	497	549	.25	2.33	2.58
1886	65	429	494	.30	1.95	2.25
1887	10	494	504	.04	2.16	2.20
1888	83	645	728	.29	2.26	2.55
1889	20	648	668	.07	2.29	2.36
1890	78	655	733	.27	2.25	2.52
1891	141	815	956	.46	2.62	3.08
1892	170	821	991	.53	2.59	3.12
1893	53	905	958	.15	2.55	2.70
1894	77	881	958	.21	2.46	2.67
1895	191	951	1,142	.51	2.53	3.04
1896	133	950	1,083	.35	2.50	2.85
1897	52	938	990	.14	2.41	2.55
1898	28	1,034	1,062	.07	2.64	2.71
1899	88	1,153	1,241	.23	2.91	3.14
1900	273	1,216	1,489	.63	2.81	3.44
1901	140	1,434	1,574	.29	2.98	3.27
1902	406	1,318	1,724	.80	2.58	3.38
1903	227	1,699	1,926	.41	3.05	3.46
1904	265	1,730	1,995	.46	3.02	3.48
1905	312	1,920	2,232	.51	3.12	3.63
1906	235	1,903	2,138	.37	3.02	3.39
1907	918	2,324	3,242	1.37	3.44	4.81
1908	348	2,097	2,445	.51	3.09	3.60
1909	498	2,144	2,642	.74	3.22	3.96
1910	485	2,336	2,821	.67	3.22	3.89
1911	429	2,237	2,666	.58	3.07	3.65
1912	251	2,168	2,419	.35	3.00	3.35
1913	464	2,321	2,785	.62	3.10	3.72
Total	6,697	43,036	49,733	.45	2.87	3.32
1914	316	2,138	2,454	.41	2.81	3.22

[a] Exceptional accidents are defined as those in which 5 or more men are killed at one time. Common accidents are those in which less than 5 men are killed at one time.

Table 43 shows, in parallel columns, by years since 1870 the number of men killed in common accidents and those killed in exceptional accidents, with fatality rates for each. For the entire period the rate for the exceptional accidents was 0.45 per 1,000 men employed, and for the common accidents 2.87. The rates for 1914 are slightly below the average. In figure 4 the total fatality rate is represented by a solid line, the common-accident rate by a dotted line, and the exceptional-accident rate by dashes. These curves show the lowest total and common-accident rates between 1885 and 1890. Since then these rates have increased to 1907, from which year there is a decline in the

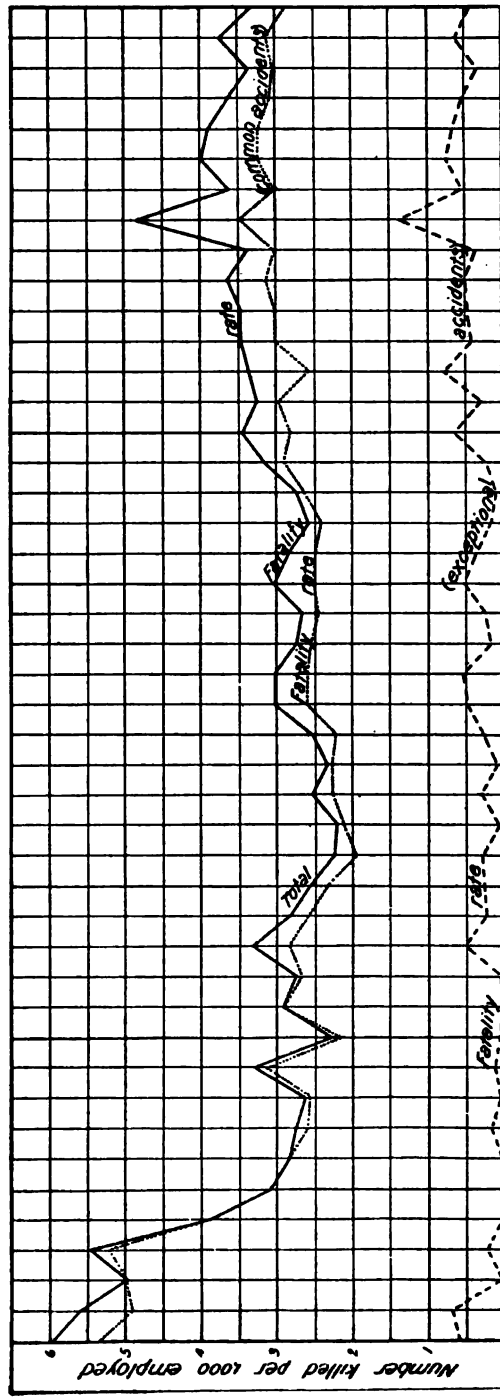


FIGURE 4.—Total number killed per 1,000 employed in coal mines of the United States; also number killed per 1,000 employed, in common and in exceptional accidents, 1870–1914. (Based on Table 42.)

fatality rate. This table shows that 6,692 men were killed in exceptional accidents since 1870, whereas the number killed in common accidents was 43,036. The number of fatalities represented in this table is based on those States for which complete inspection reports have been rendered.

Table 44 gives a *revised* list of all of the mine disasters[a] for which records are available from any source whatever since 1839 to and including 1915. This table presents details of the summary shown in Table 42.

TABLE 44.—COAL-MINE ACCIDENTS IN THE UNITED STATES IN WHICH FIVE OR MORE MEN WERE KILLED. (REVISED TO JAN. 1, 1916.)

Date.	Name of mine.	Location of mine.	Nature of accident.	Killed.
1839 Mar. 18	Black Heath	Near Richmond, Va	Mine explosion	40
1847 Feb. —	Spencer	Pottsville, Pa	do	7
1854	Chesterfield	Near Richmond, Va	do	19
1855	Midlothian	Coalfield, Va	do	55
1869 Sept. 6	Avondale	Plymouth, Pa	Mine fire	179
1870 Mar. 22	Potts	Potts Mine, Pa	Explosion of breaker boilers.	5
1870 Aug. 10	Heins & Glassmire	Middleport, Pa	Cage fell down shaft	9
1870 Aug. 29	Preston No. 3	Girardville, Pa	Cage fell down slope	7
1871 May 27	West Pittston	West Pittston, Pa	Smoke from burning breaker.	20
1871 Oct. 2	Otto Red Ash	Branch Dale, Pa	Mine explosion	5
1873 June 10	Henry Clay	Shamokin, Pa	do	10
1876 May 20	Midlothian	Coalfield, Va	do	8
1876 July 24	Black Diamond	Nortonville, Cal	do	6
1877 May 9	Wadesville	Wadesville, Pa	do	7
1877 July 11	Brookfield	Brookfield, Ohio	Suffocated by gases from mine locomotives.	7
1878 Jan. 15	Potts	Locust Dale, Pa	Mine explosion	5
1878 Nov. 21	Sullivan	Sullivan, Ind	do	8
1879 May 6	Audenried	Audenried, Pa	do	6
1879 Nov. 2	Mill Creek	Mill Creek, Pa	do	5
1880 May 3	Lykens Valley	Shamokin, Pa	do	5
1881 Feb. 10	Robbins	Robbins, Ohio	do	6
1881 Mar. 4	Almy	Almy, Wyo	do	38
1882 Feb. 3	Midlothian	Coalfield, Va	do	32
1882 May 24	Kohinoor	Shenandoah, Pa	do	5
1883 Jan. 9	Coulterville	Coulterville, Ill	do	10
1883 Feb. 16	Diamond	Braidwood, Ill	Inrush of surface water into workings.	69
1884 Jan. 24	Crested Butte	Crested Butte, Colo	Mine explosion	59
1884 Feb. 20	West Leisenring	West Leisenring, Pa	do	19
1884 Mar. 13	Laurel	Pocahontas, Va	do	112
1884 Aug. 21	Buck Ridge	Shamokin, Pa	Mine fire	7
1884 Oct. 27	Youngstown	Uniontown, Pa	Mine explosion	14
1885 Apr. 6	Cuyler	Raven Run, Pa	Fall of roof	10
1885 Aug. 11	West End	Mocanaqua, Pa	Gas from boiler fires in mine.	10
1885 Oct. 21	Plymouth No. 2	Plymouth, Pa	Mine explosion	6
1885 Dec. 18	Nanticoke No. 1	Nanticoke, Pa	Buried by inrush of quicksand.	26
1886 Jan. 13	Almy No. 4	Almy, Wyo	Mine explosion	13
1886 Jan. 21	Newburg	Newburg, W. Va	do	39
1886 Aug. 30	Fair Lawn	Scranton, Pa	do	6
1886 Sept. 13	Marvine	do	Suffocated by inrush of mine gas.	8
1886 Nov. 26	Conyngham	Wilkes-Barre, Pa	Mine explosion	12
1887 Apr. 27	Tunnel	Ashland, Pa	Suffocated by inrush of mine gas.	5
1887 Oct. 1	Bast	Big Mine Run, Pa	do	5
1888 Mar. 29	Keith & Perry No. 6	Rich Hill, Mo	Mine explosion	24
1888 Nov. 3	Kettle Creek	Clinton County, Pa	do	17
1888 Nov. 9	Shaft No. 2	Frontenac, Kans	do	40
1889 May 9	Kaska William	Middleport, Pa	Mine car fell on men in cage.	10
1889 Sept. 9	White Ash	Jefferson County, Colo	Inrush of water from old shaft.	10
1890 Feb. 1	Nottingham	Plymouth, Pa	Mine explosion	8
1890 Mar. 3	Shaft No. 3	South Wilkes-Barre, Pa	do	8
1890 Apr. 2	Susquehanna No. 4	Nanticoke, Pa	do	5
1890 May 15	Jersey No. 8	Ashley, Pa	do	26
1890 June 16	Hill Farm	Dunbar, Pa	Mine fire	31
1891 Jan. 27	Mammouth	Mount Pleasant, Pa	Mine explosion	109

[a] Horton, F. W., Coal mine accidents in the United States: Bull. 69, Bureau of Mines, 1913, p. 45.

TABLE 44.—COAL-MINE ACCIDENTS IN THE UNITED STATES IN WHICH FIVE OR MORE MEN WERE KILLED. (REVISED TO JAN. 1, 1916.)—Continued.

Date.	Name of mine.	Location of mine.	Nature of accident.	Killed.
1891 Feb. 4	Spring Mountain No. 1	Jeanesville, Pa	Drowned by inrush of water from abandoned workings and asphyxiated by gas from fire built by imprisoned men.	13
1891 Oct. 23	Richardson	Glencarbon, Pa	Imprisoned by rush of coal and suffocated by mine gas.	7
1891 Nov. 8	Susquehanna No. 1	Nanticoke, Pa	Mine explosion	12
1892 Jan. 7	No. 11	Krebs, Okla	do	100
1892 Apr. 20	Lytle	Minersville, Pa	Drowned by water from old workings.	10
1892 May 10	Roslyn	Roslyn, Wash	Mine explosion	45
1892 July 23	York Farm	Pottsville, Pa	do	15
1893 Jan. 10	Como	King, Colo	do	24
1893 Feb. 14	Chicago and Iowa	Albia, Iowa	do	8
1893 Apr. 1	Neilson	Shamokin, Pa	Mine fire	10
1893 June 22	Susquehanna No. 1	Nanticoke, Pa	Mine explosion	5
1893 Sept. 21	Lance No. 11	Plymouth, Pa	do	6
1894 Feb. 13	Gaylord	do	Fall of roof	13
1894 July 17	East Sugar Loaf	Stockton, Pa	Dynamite explosion	8
1894 Aug. 24	Franklin	Franklin, Wash	Mine fire	37
1894 Oct. 8	Luke Fidler	Shamokin, Pa	do	5
1894 Oct. 11	Henry Clay	do	Boiler explosion	6
1894 Nov. 20	Blanche	Standard, W. Va	Mine explosion	8
1895 Jan. 22	Tate	Sturgis, Ky	Powder explosion	5
1895 Feb. 18	West Bear Ridge	Mahanoy Plane, Pa	Mine explosion	5
1895 Feb. 27	White Ash	Cerrillos, N. Mex	do	24
1895 Mar. 20	Red Canyon	Red Canyon, Wyo	do	60
1895 Apr. 8	Blue Canyon	Lake Whatcom, Wash	do	23
1895 Oct. 7	Dorrance	Wilkes-Barre, Pa	do	7
1895 Dec. 19	Cumnock	Cumnock, N. C	do	39
1895 Dec. 20	Nelson	Dayton, Tenn	do	28
1896 Feb. 18	Vulcan	New Castle, Colo	do	49
1896 Mar. 23	Berwind	Dubois, Pa	do	13
1896 June 28	Twin	Pittston, Pa	Fall of roof	58
1896 Oct. 29	Shaft No. 3	South Wilkes-Barre, Pa	Mine explosion	6
1896 Dec. 26	Oswald	Princeton, Ind	do	7
1897 Jan. 4	No. 1	Alderson, Okla	do	5
1897 Jan. 13	Wadesville	Wadesville, Pa	Crosshead fell down shaft	5
1897 Mar. 4	Kansas & Texas No. 44	Huntington, Ark	Mine explosion	14
1897 Sept. 3	Sunshine	Sunshine, Colo	do	12
1897 Sept. 20	Belle Ellen	Belle Ellen, Ala	Mine fire	5
1897 Sept. 28	Jermyn No. 1	Rendham, Pa	do	5
1897 Oct. 30	Von Storch	Scranton, Pa	do	6
1898 May 26	Kaska William	Middleport, Pa	Drowned by water from old workings.	6
1898 Sept. 23	Umpire	Brownsville, Pa	Mine explosion	8
1898 Oct. 1	Midvale	Wilkes-Barre, Pa	Mine fire	5
1898 Nov. 5	Exeter	West Pittston, Pa	Mine car fell on men in cage.	9
1899 Feb. 21	Blocton No. 2	Blocton, Ala	Mine explosion	5
1899 Apr. 21	Cook & White	Madrid, N. Mex	do	5
1899 May 23	Cumnock	Cumnock, N. C	do	23
1899 July 24	Grindstone	Grindstone, Pa	do	5
1899 Dec. 9	Carbon Hill No. 7	Carbonado, Wash	do	31
1899 Dec. 23	Sumner	Sumner, Pa	do	19
1900 Mar. 6	Red Ash	Red Ash, W. Va	do	46
1900 May 1	Winter Quarters 1 and 4	Scofield, Utah	do	200
1900 Aug. 21	Issaquah No. 4	Issaquah, Wash	Smoke from burning air shaft.	5
1900 Nov. 2	Berryburg	Berryburg, W. Va	Powder explosion	15
1900 Nov. 9	Buck Mountain	Mahanoy, Pa	Mine explosion	7
1901 Feb. 25	Diamondville No. 1	Diamondville, Wyo	Mine fire	28
1901 Apr. 29	McAlester No. 5	Alderson, Okla	Blown-out or windy shot	6
1901 May 15	Chatham	Farmington, W. Va	Mine explosion	10
1901 May 27	Richland	Dayton, Tenn	do	20
1901 June 10	Port Royal No. 2	Port Royal, Pa	do	19
1901 Sept. 16	Spring Gulch	Spring Gulch, Colo	do	6
1901 Oct. 25	Buttonwood	Plymouth, Pa	do	6
1901 Oct. 26	Diamondville	Diamondville, Wyo	do	22
1901 Nov. 14	Pocahontas	Pocahontas, Va	Mine fire and explosion	9
1901 Nov. 22	do	do	Mine fire	8
1901 Dec. 28	No. 1	Hartshorne, Okla	Fell from cage	6
1902 Jan. 13	Milby & Dow	Dow, Okla	Mine fire	10
1902 Jan. 24	Lost Creek No. 2	Oskaloosa, Iowa	Mine explosion	20
1902 Mar. 6	Catsburg	Monongahela, Pa	do	5
1902 Mar. 31	Nelson	Dayton, Tenn	do	16
1902 May 19	Fraterville	Coal Creek, Tenn	do	184
1902 July 10	Rolling Mill	Johnstown, Pa	do	112
1902 Aug. 7	Bowen	Bowen, Colo	do	13

TABLE 44.—COAL-MINE ACCIDENTS IN THE UNITED STATES IN WHICH FIVE OR MORE MEN WERE KILLED. (REVISED TO JAN. 1, 1916.)—Continued.

Date.	Name of mine.	Location of mine.	Nature of accident.	Killed.
1902 Sept. 15	Algoma No. 7	Algoma, W. Va	Mine explosion	17
1902 Sept. 22	Stafford	Stafford, W. Va	....do	6
1902 Oct. 1	Lawson	Black Diamond, Wash	....do	11
1902 Nov. 29	Luke Fidler	Shamokin, Pa	....do	7
1902 Dec. 9	South Wilkes-Barre	South Wilkes-Barre, Pa	Dynamite explosion	5
1903 Mar. 15	Cardiff	Cardiff, Ill	Mine explosion	5
1903 Mar. 23	Athens No. 2	Athens, Ill	Windy shot	6
1903 Mar. 31	Sandoval	Sandoval, Ill	Blown-out shot	8
1903 Apr. 12	Central Slope 77	Carbon, Okla	Mine explosion	6
1903 June 19	Blossburg No. 3	Blossburg, N. Mex	Powder explosion	5
1903 June 30	Hanna No. 1	Hanna, Wyo	Mine explosion and fire	169
1903 Nov. 20	Bonanza No. 20	Bonanza, Ark	Mine explosion	11
1903 Nov. 21	Ferguson	Connellsville, Pa	....do	17
1904 Jan. 25	Harwick	Cheswick, Pa	....do	179
1904 Jan. 30	Maple Hill	Mahanoy City, Pa	Dynamite explosion	5
1904 Apr. 20	Stearns No. 5	Stearns, Ky	Mine explosion	5
1904 May 5	Lance	Plymouth, Pa	Dynamite explosion	5
1904 ...do....	Locust Gap	Locust Gap, Pa	Mine fire	5
1904 May 11	Big Muddy	Herrin, Ill	Powder explosion	10
1904 May 25	Williamstown	Williamstown, Pa	Suffocated by gases from locomotive.	10
1904 Oct. 28	Tercio	Tercio, Colo	Mine explosion	19
1904 Nov. 2	Auchincloss	Nanticoke, Pa	Fell down shaft	10
1904 Dec. 7	No. 5	Burnett, Wash	Mine explosion	17
1905 Jan. 16	Decatur	Decatur, Ill	Mine fire	6
1905 Feb. 18	Lytle	Minersville, Pa	Fall of roof	5
1905 Feb. 20	Virginia City	Virginia City, Ala	Mine explosion	108
1905 Feb. 26	Grapevine	Wilcoe, W. Va	....do	6
1905 Mar. 9	Clear Spring	West Pittston, Pa	Fell down shaft	7
1905 {Mar. 18 / Mar. 19}	Rush Run and Red Ash	Red Ash, W. Va	Mine explosion	24
1905 Mar. 22	Oswald	Princeton, Ind	....do	9
1905 Apr. 3	Leiter	Zeigler, Ill	....do	49
1905 Apr. 20	Cabin Creek	Kayford, W. Va	Powder explosion	6
1905 Apr. 26	Conyngham	Wilkes-Barre, Pa	Fell down shaft	10
1905 Apr. 27	Eleanora	Dubois, Pa	Mine explosion	13
1905 Apr. 30	No. 19	Wilburton, Okla	....do	13
1905 July 6	Fuller	Searight, Pa	....do	6
1905 Oct. 13	Clyde	Fredericktown, Pa	Mine fire	6
1905 Oct. 29	Hazel Kirk No. 2	Monongahela, Pa	Mine explosion	5
1905 Nov. 4	Tidewater	Vivian, W. Va	....do	7
1905 Nov. 15	Braznell	Bentleyville, Pa	....do	7
1905 Dec. 1	Diamondville No. 1	Diamondville, Wyo	....do	18
1905 Dec. 4	Horton	Horton, W. Va	Mine fire	7
1906 Jan. 4	Coaldale	Coaldale, W. Va	Mine explosion	22
1906 Jan. 18	Detroit	Detroit, W. Va	....do	18
1906 Jan. 24	Poteau No. 6	Witteville, Okla	Dynamite explosion	14
1906 Feb. 8	Parral	Parral, W. Va	Mine explosion	23
1906 Feb. 19	Maitland	Walsenburg, Colo	....do	14
1906 Feb. 27	Little Cahaba	Piper, Ala	....do	12
1906 Mar. 22	Century No. 1	Century, W. Va	....do	23
1906 Apr. 22	Cuatro	Tercio, Colo	....do	18
1906 May 15	Shenandoah City	Shenandoah, Pa	Dynamite explosion	7
1906 June 7	Red Lodge	Red Lodge, Mont	Mine fire	8
1906 Aug. 6	Susquehanna No. 7	Nanticoke, Pa	Mine explosion	6
1906 Oct. 3	Pocahontas	Pocahontas, Va	....do	35
1906 Oct. 5	Dutchman	Blossburg, N. Mex	....do	10
1906 Oct. 24	Rolling Mill	Johnstown, Pa	....do	7
1906 Nov. 3	San Toy No. 1	Corning, Ohio	Fell down shaft	5
1906 Dec. 20	Fidelity No. 1	Stone City, Kans	Powder explosion	7
1906 Dec. 22	Breese-Trenton	Breese, Ill	Cage with men fell down shaft.	6
1907 Jan. 14	Deering No. 7	Clinton, Ind	Powder explosion	7
1907 Jan. 23	Primero	Primero, Colo	Mine explosion	24
1907 Jan. 26	Lorentz	Penco, W. Va	Powder explosion	12
1907 Jan. 29	Johnston City	Johnston City, Ill	....do	7
1907 ...do....	Stuart	Stuart, W. Va	Mine explosion	84
1907 Feb. 4	Thomas No. 25	Thomas, W. Va	....do	25
1907 Mar. 2	Holden	Taylor, Pa	....do	7
1907 Mar. 16	Bond and Bruce	Tacoma, Va	....do	11
1907 Apr. 26	Morgan	Black Diamond, Wash	....do	7
1907 May 1	Whipple	Scarboro, W. Va	....do	16
1907 May 19	Engleville	Engleville, Colo	Mine fire	5
1907 June 18	Johnson No. 1	Priceburg, Pa	Mine explosion	7
1907 Aug. 17	Sonman	Sonman, Pa	Fell down shaft	5
1907 Dec. 1	Naomi	Fayette City, Pa	Mine explosion	34
1907 Dec. 6	Monongah Nos. 6 and 8	Monongah, W. Va	....do	361
1907 Dec. 16	Yolande	Yolande, Ala	....do	56
1907 Dec. 19	Darr	Jacobs Creek, Pa	....do	239
1907 Dec. 31	Bernal	Carthage, N. Mex	....do	11
1908 Jan. 30	Backman	Hawks Nest, W. Va	....do	9

TABLE 44.—COAL-MINE ACCIDENTS IN THE UNITED STATES IN WHICH FIVE OR MORE MEN WERE KILLED. (REVISED TO JAN. 1, 1916.)—Continued.

Date.	Name of mine.	Location of mine.	Nature of accident.	Killed.
1908 Feb. 10	Moody	South Carrollton, Ky.	Mine explosion	9
1908 Mar. 28	Hanna No. 1	Hanna, Wyo.	do	59
1908 May 12	Mount Lookout	Wyoming, Pa.	do	12
1908 May 13	Prospect	Midvale, Pa.	Fall of roof	5
1908 July 15	Williamstown	Williamstown, Pa.	Powder explosion	6
1908 Aug. 26	Hailey-Ola No. 1	Haileyville, Okla.	Mine fire	29
1908 Aug. 28	Warrior Run	Wilkes-Barre, Pa.	Mine cars	6
1908 Nov. 20	Red Lodge	Red Lodge, Mont.	Mine fire	9
1908 Nov. 28	Rachel and Agnes	Marianna, Pa.	Mine explosion	154
1908 Dec. 29	Lick Branch	Switchback, W. Va.	do	50
1909 Jan. 10	Zeigler	Zeigler, Ill.	Mine fire and explosion	26
1909 Jan. 12	Lick Branch	Switchback, W. Va.	Mine explosion	67
1909 Jan. 19	Stone Canyon	Chancellor, Cal.	do	6
1909 Jan. 25	Washington No. 5	Franklin, Md.	Mine cars (surface)	5
1909 ...do...	Orenda No. 2	Boswell, Pa.	Mine explosion	5
1909 Feb. 2	Short Creek	Short Creek, Ala.	do	16
1909 Mar. 2	No. 14	Pittston, Pa.	do	8
1909 Mar. 20	Sunnyside	Evansville, Ind.	do	6
1909 Mar. 31	Echo	Buery, W. Va.	Dynamite explosion	6
1909 Apr. 9	Eureka No. 37	Windber, Pa.	do	7
1909 June 23	Lackawanna No. 4	Wehrum, Pa.	Mine explosion	21
1909 July 6	Toller	Tollerville, Colo.	do	9
1909 Oct. 3	Northwestern	Roslyn, Wash.	do	10
1909 Oct. 21	Rock Island No. 8	Hartshorne, Okla.	do	10
1909 Oct. 31	Franklin No. 2	Johnstown, Pa.	do	13
1909 Nov. 9	Auchincloss	Nanticoke, Pa.	Mine fire	9
1909 Nov. 13	St. Paul No. 2	Cherry, Ill.	do	259
1909 Dec. 11	Baker No. 5	Clay, Ky.	Mine explosion	7
1909 Dec. 23	Mine A	Herrin, Ill.	do	8
1910 Jan. 11	Nottingham	Plymouth, Pa.	do	7
1910 Jan. 31	Primero	Primero, Colo.	do	75
1910 Feb. 1	Browder	Browder, Ky.	do	34
1910 Feb. 5	Ernest No. 2	Ernest, Pa.	do	12
1910 Feb. 8	Barthell No. 1	Stearns, Ky.	do	6
1910 Mar. 12	South Wilkes-Barre No. 5	Wilkes-Barre, Pa.	do	7
1910 Mar. 31	Great Western No. 2	Wilburton, Okla.	do	6
1910 Apr. 20	Mulga	Mulga, Ala.	do	40
1910 Apr. 21	Amsterdam	Amsterdam, Ohio	do	15
1910 May 5	Palos No. 3	Palos, Ala.	do	83
1910 Oct. 8	Starkville	Starkville, Colo.	do	56
1910 Nov. 3	Yolande No. 1	Yolande, Ala.	do	5
1910 Nov. 6	Lawson	Black Diamond, Wash.	do	16
1910 Nov. 8	Victor American No. 3	Delagua, Colo.	Mine fire and explosion	79
1910 Nov. 11	Shoal Creek No. 1	Panama, Ill.	Mine explosion	6
1910 Nov. 25	Providence No. 3	Providence, Ky.	Powder explosion	10
1910 Dec. 14	Greeno	Tacoma, Va.	Mine explosion	8
1910 ...do...	Leyden	Leyden, Colo.	Mine fire	10
1910 Dec. 31	Lick Fork	Thacker, W. Va.	Mine cars	10
1911 Jan. 20	Carbon Hill	Carbon Hill, Va.	Mine explosion	5
1911 Feb. 9	Cokedale	Trinidad, Colo.	do	17
1911 Mar. 18	No. 16	Mineral, Kans.	do	5
1911 Mar. 22	Hazel	East Canonsburg, Pa.	Fall of roof	9
1911 Apr. 7	Price-Pancoast	Throop, Pa.	Mine fire	72
1911 Apr. 8	Banner	Littleton, Ala.	Mine explosion	128
1911 Apr. 24	Ott No. 20	Elk Garden, W. Va.	do	23
1911 May 27	Cameron	Shamokin, Pa.	do	5
1911 July 13	Sykesville	Sykesville, Pa.	do	21
1911 Sept. 12	Marvine	Scranton, Pa.	Mine cars	5
1911 Oct. 3	Drifton No. 2	Freeland, Pa.	Cave-in	5
1911 Oct. 23	O'Gara No. 9	Harrisburg, Ill.	Mine explosion	8
1911 Nov. 9	Adrian	Punxsutawney, Pa.	do	8
1911 Nov. 18	Bottom Creek	Vivian, W. Va.	do	18
1911 Dec. 9	Cross Mountain	Briceville, Tenn.	do	84
1912 Jan. 9	Parrish	Plymouth, Pa.	do	6
1912 Jan. 16	Carbon Hill	Carbon Hill, Va.	Dynamite explosion	5
1912 Jan. 19	Central	Central City, Ky.	Mine explosion	5
1912 Jan. 20	Kemmerer No. 4	Kemmerer, Wyo.	do	6
1912 Feb. 22	Western No. 5	Lehigh, Okla.	Mine fire	9
1912 Mar. 20	San Bois No. 2	McCurtain, Okla.	Mine explosion	73
1912 Mar. 26	Jed	Jed, W. Va.	do	81
1912 Apr. 21	Coll	Madisonville, Ky.	do	5
1912 June 18	Hastings	Hastings, Colo.	do	12
1912 July 11	Panama	Moundsville, W. Va.	do	8
1912 July 16	Old Dominion No. 1	Carbon Hill, Va.	do	8
1912 July 24	Superba and Lemont	Evans Station, Pa.	Cloudburst flooded mine	a 18
1912 Aug. 13	Abernant	Abernant, Ala.	Mine explosion	18
1913 Feb. 19	Seagraves	Eldorado, Ill.	do	5
1913 Apr. 23	Cincinnati	Finleyville, Pa.	do	96
1913 May 6	Taylor	Hartford, Ky.	Overcome by gas	5
1913 May 17	Imperial	Belle Valley, Ohio	Mine explosion	15

a Not included in State inspector's statement of mine fatalities.

TABLE 44.—COAL-MINE ACCIDENTS IN THE UNITED STATES IN WHICH FIVE OR MORE MEN WERE KILLED. (REVISED TO JAN. 1, 1916.)—Continued.

Date.	Name of mine.	Location of mine.	Nature of accident.	Killed.
1913 Aug. 2	East Brookside	Tower City, Pa	Mine explosion	19
1913 Oct. 22	Stag Canon No. 2	Dawson, N. Mex	do	263
1913 Nov. 18	Acton No. 2	Acton, Ala	do	24
1913 Dec. 16	Vulcan	New Castle, Colo	do	37
1914 Jan. 10	Rock Castle	Rock Castle, Ala	do	12
1914 Jan. 14	Spencer-Newland	Mulberry, Kans	Cage with men fell down shaft.	6
1914 Apr. 28	Eccles Nos. 5 and 6	Eccles, W. Va	Mine explosion	181
1914 Apr. 29	Union Pacific No. 2	Cumberland, Wyo	Mine cars	5
1914 May 29	Maryd	Maryd, Pa	Overwinding of cage	6
1914 June 30	Cinderella	Cinderella, W. Va	Suffocated by fumes from fire in fan house.	5
1914 Sept. 4	No. 1	Adamson, Okla	Cave-in	13
1914 Sept. 16	Lehigh No. 4	Lansford, Pa	Mine explosion	7
1914 Oct. 5	Mulga	Mulga, Ala	do	16
1914 Oct. 27	North or No. 1	Royalton, Ill	do	52
1914 Dec. 9	Tripp	Scranton, Pa	Collapse of bottom of cage.	13
1915 Feb. 6	Carlisle	Carlisle, W. Va	Mine explosion	21
1915 Feb. 17	Prospect	Wilkes-Barre, Pa	do	13
1915 Feb. 18	Atlas	Rich Hill, Mo	Powder and mine explosion.	5
1915 Mar. 2	Layland No. 3	Layland, W. Va	Mine explosion	112
1915 Apr. 5	Shoal Creek	Panama, Ill	do	11
1915 May 24	Smokeless Valley No. 1	Johnstown, Pa	do	9
1915 July 27	United Coal No. 1	Christopher, Ill	do	9
1915 July 30	Patterson No. 2	Elizabeth, Pa	Mine cars	9
1915 Aug. 31	Orenda	Boswell, Pa	Mine explosion	19
1915 Nov. 16	Northwestern	Ravensdale, Wash	do	31
1915 Nov. 30	Boomer No. 2	Boomer, W. Va	do	23

GAS AND DUST EXPLOSIONS.

Table 45 shows the number of men killed by gas and dust explosions in the coal mines of the United States, by States, during indicated periods ending December 31, 1913, for which continuous records are available. This table takes cognizance of 6,726 fatalities in the coal mines of the United States due to this cause alone, including both common and exceptional accidents. In addition to these accidents a number of mine disasters occurred prior to the beginning of State mine inspection, which are not included in this table. During the periods covered, the fatalities due to gas and dust explosions were 13.88 per cent of the total number killed, or a fatality rate of 0.46 per 1,000 men employed.

Utah has the highest percentage of fatalities in important coal mining States due to this cause, the rate being 57.75 per cent of the total, or 5.34 per 1,000 men employed. Utah's high rate is due to one disaster at the Winter Quarters mine, in which 200 men were killed at one time. New Mexico has the next highest percentage, 56.51 per cent of the total fatalities for a period of 21 years, or 6.46 per 1,000 men employed. This high rate is due to the Dawson disaster, in which 263 men were killed at one time.

The percentage of fatalities due to gas and dust explosions in some of the States is much higher than in others, whereas the rate per 1,000 men employed may not be in accordance therewith. Here again is shown the fallacy of making fatality comparisons on the percentage basis. In Utah and New Mexico the percentage of fatalities due to

falls of roof, 26.76 and 28.17, respectively, indicates exceedingly safe roof conditions in the mines of these States, as this rate is about one-half the average for the United States, which is 47.49 per cent. But the fatality rate due to falls of roof, based on the number of men employed, in New Mexico is 3.22 and in Utah 2.48, both of which are much larger than the average for the United States, which is 1.57 per 1,000 men employed.

TABLE 45.—NUMBER OF MEN KILLED BY GAS AND DUST EXPLOSIONS IN AND ABOUT THE COAL MINES OF THE UNITED STATES, BY STATES, DURING PERIOD SHOWN ENDED DEC. 31, 1913, FOR WHICH CONTINUOUS RECORDS ARE AVAILABLE.

State.	Number of years in period ended Dec. 31, 1913.	Number killed.		
		Total.	Per cent.	Per 1,000 employed.
Alabama	21	620	33.32	1.75
Arkansas	9	2	1.87	.05
Colorado	28	517	29.75	2.12
Georgia	5	.....	.....	.....
Illinois	29	170	4.99	.13
Indiana	19	57	8.39	.18
Iowa	26	44	6.10	.13
Kansas	21	33	6.25	.15
Kentucky	26	74	11.65	.23
Maryland	23	.....	.....	.....
Michigan	14	.....	.....	.....
Missouri	26	40	10.58	.19
Montana	14	.....	.....	.....
New Mexico	21	321	56.51	6.46
North Dakota	6	.....	.....	.....
Ohio	30	64	2.79	.07
Oklahoma	21	262	35.94	1.96
Oregon	5	2	66.67	1.79
Pennsylvania (anthracite)	44	1,344	7.59	.26
Pennsylvania (bituminous)	36	1,308	13.82	.40
Tennessee	23	339	39.47	1.70
Texas	5	.....	.....	.....
Utah	22	205	57.75	5.34
Virginia	5	25	9.96	.63
Washington	25	195	30.47	1.87
West Virginia	29	1,036	21.82	1.09
Wyoming	6	67	27.80	1.45
Total[a]	.....	6,726	13.88	.46

[a] This table is based on Table 5, and is for periods indicated, by States, for which continuous records are available. It does not necessarily check with Tables 3 and 4, for the reason that the latter tables include intermittent records prior to the period having continuous records.

It will be noted from figure 3 that the accidents due to gas and dust explosions were comparatively few from 1875 to 1890, the rate being about 0.30 per 1,000 men employed. Beginning with 1890 the fatality rate has been very irregular, owing to the irregular occurrence of large diasters. The climax was reached in 1907, when seven explosions occurred, in each of which more than 20 men were killed. The number killed by gas and dust explosions in 1907 was 1.417 per 1,000 employed in all coal mines, or 1.796 (Table 68) per 1,000 for the bituminous mines alone. As shown in Table 4, the fatality rate due to this cause has declined since 1907, being 0.457 per 1,000 in 1914 as compared with the average of 0.487 from 1870 to 1913.

In considering the number of men killed in recent gas and dust explosions, it must not be forgotten that the mines are becoming

deeper, contain more abandoned rooms and old workings, with the possibility of greater accumulations of gas and dust, are larger, and that more men are employed in the individual mines than in former years, so that when an explosion does occur, there is the possibility of trapping more men than would have happened in the same mine 20 or 25 years ago.

With deeper mines and the resultant old workings, ventilation is not as easy to maintain as in the newer mines, thus permitting the accumulation of gas and dust. The deep slope or shaft mines drain all of the water from the upper workings, leaving the haulage ways and rooms dry, with the result that coal dust will be produced and accumulate in them. Water also drains from the gob and waste piles and they become comparatively dry. Air will circulate through abandoned rooms, caved workings and gob, and in so doing the velocity of the air current is reduced and the suspended dust deposited. The air is actually filtered, leaving its deadly burden of dust to be ignited by an explosion of gas or a blown-out shot.

MINE FIRES.

Table 46 shows a list of the principal mine fires which have occurred in the United States since 1869, and in which 1,053 men have been killed. This table does not necessarily check with Table 3, for the reason that it includes one disaster in 1869 not shown in Table 3;

TABLE 46.—MINE FIRES IN THE UNITED STATES IN WHICH FIVE OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Killed.
1869 Sept. 6	Avondale	Plymouth, Pa.	179
1884 Aug. 21	Buck Ridge	Shamokin, Pa.	7
1890 June 16	Hill Farm	Dunbar, Pa.	31
1893 Apr. 1	Neilson	Shamokin, Pa.	10
1894 Aug. 24	Franklin	Franklin, Wash.	37
1894 Oct. 8	Luke Fidler	Shamokin, Pa.	5
1897 Sept. 20	Belle Ellen	Belle Ellen, Ala.	5
1897 Sept. 28	Jermyn No. 1	Rendham, Pa.	5
1897 Oct. 30	Von Störch	Scranton, Pa.	6
1898 Oct. 1	Midvale	Wilkes-Barre, Pa.	5
1901 Feb. 25	Diamondville No. 1	Diamondville, Wyo.	28
1901 Nov. 14	Pocahontas	Pocahontas, Va.	9
1901 Nov. 22	do	do	8
1902 Jan. 13	Milby & Dow	Dow, Okla.	10
1903 June 30	Hanna No. 1	Hanna, Wyo.	[a] 169
1904 May 5	Locust Gap	Locust Gap, Pa.	5
1905 Jan. 16	Decatur	Decatur, Ill.	6
1905 Oct. 13	Clyde	Fredericktown, Pa.	6
1905 Dec. 4	Horton	Horton, W. Va.	7
1906 June 7	Red Lodge	Red Lodge, Mont.	8
1907 May 19	Engleville	Engleville, Colo.	5
1908 Aug. 26	Hailey-Ola No. 1	Haileyville, Okla.	29
1908 Nov. 20	Red Lodge	Red Lodge, Mont.	9
1909 Jan. 10	Zeigler	Zeigler, Ill.	[a] 26
1909 Nov. 9	Auchincloss	Kingston, Pa.	9
1909 Nov. 13	St. Paul No. 2	Cherry, Ill.	259
1910 Nov. 8	Victor American No. 3	Delagua, Colo.	[a] 79
1910 Dec. 14	Leyden	Leyden, Colo.	10
1911 Apr. 7	Price-Pancoast	Throop, Pa.	72
1912 Feb. 22	Western No. 5	Lehigh, Okla.	9
Total			1,053

[a] Fire and explosion combined.

it also includes 3 disasters in which a mine fire and explosion were combined. Table 47 shows a list of mine fires at mines in the United Kingdom that were due to spontaneous combustion. This table brings out forcibly the dangers due to spontaneous combustion of waste material stored underground. Too much care can not be exercised in the matter of taking care of waste material, such as waste in engine rooms and pump stations, and old timbers, which may be easily ignited should they come in contact with oil-saturated waste. Timber should not be stored with the mine gob where oxidation is likely to take place, as it will add fuel to a fire which may be easily started. All inflammable material should be removed from the mines.

TABLE 47.—LOSS OF LIFE OCCASIONED BY FIRES DUE TO SPONTANEOUS COMBUSTION IN MINES IN THE UNITED KINGDOM, 1893–1912, INCLUSIVE.[a]

Date of accident.	Name of mine.	County.	Number killed.	Number injured.	Reported cause of death.
1894 Oct. 16	Harecastle and Woodshutts.	North Staffordshire...	1	1	Skull fractured by explosion blowing out stopping.
1895 Oct. 29	Oldfield.....	.....do.....	2	1	Suffocated by fumes and smoke.
1896 Sept. 10	Shelton.....	.....do.....	1	.....	Carbon monoxide poisoning.
1898 Apr. 19	Whitwick.....	Leicester.....	35	6	Suffocated by fumes from burning timbers.
1899 Mar. 11	Cadeby Main..	Yorkshire.....	2	2	Explosion ignited by gob fire while working in a "scouring."
1899 Oct. 20	Dalquharran..	Ayrshire.....	1	.....	Suffocated by fumes; gob fire.
1901 Feb. 15	Hill of Beath..	Fife.....	7	.....	Poisoned by carbon monoxide leaking through stoppings.
1901 Nov. 7	Talk o' the Hill	North Staffordshire...	4	.....	Explosion ignited by gob fire.
1902 June 19	Hamstead.....	South Staffordshire...	2	.....	Carbon monoxide poisoning.
1904 Aug. 28	Melgund.....	Fife.....	1	1	Suffocated by products of combustion.
1905 June 24	Coneygre, No. 126 pit.	South Staffordshire...	1	.....	Carbon monoxide and black damp poisoning.
1905 June 25	Haden Hill....	.....do.....	2	.....	Do.
1905 Aug. 28	Hamstead.....	.....do.....	1	.....	Carbon monoxide poisoning.
1906 Apr. 27	Lumphinnans, No. 1 pit.	Fife.....	2	.....	Do.
1906 May 26	Bog, Nos. 1 and 2 pits.	Lanark.....	2	1	Carbon monoxide suffocation.
1906 June 1	Court Herbert.	Glamorgan.....	5	4	Shock of explosion ignited by gob fire.
1907 July 14	Aldridge.....	South Staffordshire...	1	.....	Suffocated by fumes.
1907 Dec. 29	Lochhead.....	Fife.....	3	.....	Carbon monoxide poisoning.
1908 Dec. 23	Cakemore.....	Worcester.....	3	2	Severe burns.
1910 Apr. 17	Windmillend, No. 5 pit.	.....do.....	2	.....	Carbon monoxide poisoning.
1911 Nov. 25	Bignall Hill, Jamage pit.	North Staffordshire...	6	14	Do.
1912 Feb. 2	Bentley.....	Yorkshire.....	3	4	Explosion ignited by gob fire.
1912 Feb. 24	Norton.....	North Staffordshire...	1	1	Do.
1912 July 9	Cadeby Main..	Yorkshire.....	88	.....	Do.
1912 Oct. 27	Cae Duke.....	Glamorgan.....	1	.....	Carbon monoxide poisoning.
Total...	.....	.....	177	37	

[a] First report of the departmental committee on spontaneous combustion of coal in mines, Home Office, London, 1914.

EXPLOSIVES.

Table 48 shows by causes and States the total number of fatalities due to explosives, during periods of inspection service for which continuous records are available. The fatality rates due to explosives from 1870 to 1914 are shown in figure 3. In Table 48 are tabulated 3,675 fatalities due to the use of explosives underground. This table has been divided into 14 subheadings showing various causes of accidents while using explosives, and it will be noted that 24.87 per cent are due to premature blasts, 16.79 per cent to handling and transportation, 16.71 per cent to flying pieces of rock or coal. The number of fatalities due to striking unexploded charges in removing débris is small, only three being reported. The small number of fatalities due to thawing of explosives is largely accounted for by the fact that black powder is used to such a large extent in the coal mines. Dynamite is not used so extensively and hence there are not so many accidents due to thawing as in the metal mines, where dynamite is used almost exclusively. Of the 27 fatalities due to thawing explosives, 21 occurred in the anthracite mines of Pennsylvania, where a large amount of dynamite is used. The table presents a detailed study which has not heretofore been available, and it is hoped that it will be of some special use to safety engineers in forming rules and regulations concerning the use of explosives.

The table also gives the percentage of fatalities and the rate per 1,000 men employed. In Kansas and North Dakota nearly one-fourth of all coal-mine fatalities is due to the use of explosives. Although in Indiana 19.44 per cent and in Oklahoma 15.77 per cent are due to this cause, the average for the United States is 7.59 per cent.

Table 49 gives the number of fatalities due to explosives in and about the anthracite mines of Pennsylvania from 1870 to and including 1913. This table shows that 1,835 fatalities were due to this cause alone, of which 1,790 were underground, as indicated in Table 48. Table 49 also shows the fatality rate per 1,000 men employed as being 0.225 in 1870. This rate fluctuates more or less, but it has more than doubled in recent years, ranging from 0.414 in 1909 to 0.540 in 1908 and 0.427 in 1913. The average fatality rate per 1,000 men employed in the anthracite field during the entire period of 44 years is 0.354, as compared with 0.05 in the bituminous fields of Pennsylvania, in which there were 185 fatalities as compared with 1,790 in the anthracite field.

Anthracite coal being much harder than bituminous coal, more nearly approaches metal-mining operations, and of course larger quantities of more powerful explosives are required. Table 50 shows that the amount of explosives used in the anthracite field is practically three times the amount used in the bituminous mines of

TABLE 48.—NUMBER OF MEN KILLED BY EXPLOSIVES IN THE COAL MINES (UNDERGROUND ONLY) OF THE UNITED STATES, BY STATES, DURING PERIOD SHOWN ENDED DEC. 31, 1913, FOR WHICH CONTINUOUS RECORDS ARE AVAILABLE.[a]

State.	Number of years in period ended Dec. 31, 1913.	Handling and transportation.	Handling caps, detonators, squibs, and fuse.	Thawing explosives.	Tamping.	Premature blast and short fuse.	Blown-out or windy shot.	Flying pieces of rock or coal.	Returned too soon.	Delayed blast.	Shot breaking through pillar or rib.	Suffocation by powder gas.	Striking unexploded charge in removing débris.	Drilling into unexploded charge.	Unclassified.	Total.	Percentage of total killed in State.	Number killed per 1,000 employed.
Alabama	21	7	.....	.....	2	10	12	8	16	1	2	1	.....	.....	37	96	5.16	0.27
Arkansas	9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15	15	14.01	.34
Colorado	28	2	2	.....	.....	19	3	5	2	2	1	6	.....	9	9	60	3.45	.25
Georgia	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	14.29	.43
Illinois	29	86	1	.....	10	94	81	47	52	3	32	7	.....	14	32	459	13.47	.34
Indiana	19	23	.....	.....	3	28	16	6	12	3	12	19	.....	2	8	132	19.44	.42
Iowa	26	9	1	.....	.....	18	4	25	3	.....	4	1	.....	2	7	74	10.25	.23
Kansas	21	11	9	.....	1	13	19	22	3	.....	3	29	.....	.....	21	131	24.81	.61
Kentucky	26	13	4	.....	.....	11	17	3	13	1	7	6	.....	4	10	89	14.02	.28
Maryland	23	2	1	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	5	2.27	.04
Michigan	14	.....	1	.....	.....	6	.....	2	.....	1	1	1	.....	.....	3	15	15.31	.33
Missouri	26	3	.....	.....	.....	4	.....	8	8	2	5	8	.....	1	4	43	11.38	.20
Montana	14	2	.....	1	.....	.....	.....	1	1	.....	2	1	.....	.....	3	11	6.92	.27
New Mexico	21	.....	.....	.....	.....	4	5	5	1	3	1	1	.....	2	2	24	4.23	.48
North Dakota	6	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	2	3	23.08	.72
Ohio	30	19	2	.....	.....	42	1	12	8	2	24	7	.....	.....	44	161	7.02	.17
Oklahoma	21	16	1	.....	.....	9	19	14	10	3	6	6	.....	.....	31	115	15.77	.86
Oregon	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	.....	.....
Pennsylvania (anthracite)	44	318	10	21	88	583	.....	420	126	9	77	10	3	26	99	1,790	10.10	.35
Pennsylvania (bituminous)	36	45	6	1	2	34	13	31	19	1	24	3	.....	3	3	185	1.95	.05
Tennessee	23	3	.....	.....	.....	2	5	2	4	.....	3	5	.....	.....	25	49	5.70	.25
Texas	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	2	8.00	.09
Utah	22	1	.....	.....	.....	3	.....	1	.....	.....	.....	.....	.....	.....	.....	5	1.40	.13
Virginia	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	10	3.98	.25
Washington	25	2	2	2	.....	1	.....	.....	1	2	1	15	.....	3	3	32	5.00	.30
West Virginia	29	54	4	2	3	30	6	2	7	.....	10	1	.....	1	35	155	3.27	.16
Wyoming	6	1	.....	.....	.....	2	.....	.....	6	.....	1	.....	.....	2	1	13	5.40	.28
Total[b]	.....	617	44	27	109	914	201	614	293	33	216	127	3	69	408	3,675	7.59	.25
Percentage of total	.....	16.79	1.20	0.73	2.97	24.87	5.47	16.71	7.97	0.90	5.88	3.45	0.08	1.88	11.10	100.00	.....	.....

[a] Compiled from the annual reports of the State mine inspectors.

[b] This table is based on Table 5, and is for periods indicated by States for which continuous records are available. It does not necessarily check with Tables 3 and 4 for the reason that the latter tables include intermittent records prior to the period having continuous records.

Pennsylvania. In 1913 the bituminous fields used 14,652,931 pounds of black powder as compared with 44,001,660 pounds in the anthracite mines. The bituminous mines for the same year used 696,162 pounds of dynamite, whereas the anthracite mines used in the same period 16,093,035 pounds. The amount of permissible explosives used in the bituminous fields was 6,715,028 pounds as compared with 3,323,645 in the anthracite fields. Records showing the use of permissible explosives are not complete prior to 1909.

TABLE 49.—FATALITIES IN AND ABOUT THE ANTHRACITE MINES OF PENNSYLVANIA DUE TO EXPLOSIVES.

Year.	Number killed by—														Total.	Number killed per 1,000 employed.[a]
	Handling and transportation.	Handling caps, detonators, squibs, and fuse.	Thawing explosives.	Tamping.	Premature blast or short fuse.	Blown-out or windy shot.	Flying pieces of coal or rock.	Returned too soon.	Delayed blast.	Shot breaking through pillar or rib.	Suffocation by powder gas.	Striking unexploded charge in removing débris.	Drilling into unexploded charge.	Miscellaneous causes.		
1870	1	.....	.....	....	2	....	4	.....	....	.....	....	.....	.....	1	8	0.225
1871	4	.....	.....	....	4	....	5	1	....	1	....	.....	.....	1	16	.427
1872	4	.....	.....	....	6	....	5	.....	....	1	....	.....	.....	....	16	.358
1873	1	.....	.....	....	9	....	4	2	....	.....	....	.....	.....	....	16	.332
1874	2	.....	.....	2	4	....	3	1	....	1	....	.....	1	....	14	.262
1875	9	.....	.....	1	7	....	10	2	....	1	....	.....	.....	....	30	.429
1876	15	.....	.....	1	2	....	10	1	....	1	1	.....	2	....	33	.468
1877	3	.....	.....	1	1	....	5	.....	....	1	1	.....	.....	....	12	.179
1878	6	.....	.....	....	5	....	4	1	....	.....	....	.....	1	....	17	.266
1879	7	.....	.....	1	3	....	2	2	....	1	....	.....	1	....	17	.247
1880	.....	.....	.....	1	6	....	1	2	....	1	....	.....	.....	....	11	.150
1881	2	.....	.....	....	5	....	7	3	....	1	....	.....	.....	1	19	.250
1882	5	.....	.....	1	3	....	7	2	....	2	....	.....	.....	1	21	.256
1883	9	.....	.....	2	20	....	4	3	....	2	1	.....	.....	....	41	.449
1884	3	.....	.....	....	12	....	13	4	....	2	....	.....	1	....	35	.346
1885	9	.....	.....	3	8	....	2	3	....	3	....	.....	2	....	30	.299
1886	3	.....	.....	1	5	....	12	5	....	.....	....	.....	.....	....	26	.252
1887	4	.....	.....	....	6	....	9	.....	....	.....	....	.....	.....	1	20	.188
1888	6	.....	.....	3	17	....	6	2	....	1	....	.....	1	2	38	.311
1889	3	.....	.....	2	11	....	8	3	....	2	....	.....	.....	4	33	.267
1890	.....	.....	.....	1	7	....	4	3	....	3	....	.....	.....	....	18	.143
1891	6	.....	3	3	22	....	3	4	....	2	....	.....	1	....	44	.348
1892	6	.....	.....	....	14	....	8	2	....	5	....	.....	1	....	36	.279
1893	5	.....	1	1	14	....	11	4	....	2	....	.....	1	2	41	.308
1894	14	.....	1	6	12	....	10	2	....	1	....	.....	.....	....	46	.350
1895	14	.....	2	1	16	....	5	1	....	6	....	.....	3	4	52	.364
1896	5	.....	.....	1	13	....	13	3	....	3	....	.....	.....	....	38	.255
1897	7	1	.....	2	18	....	9	9	....	4	1	.....	.....	....	51	.340
1898	4	1	.....	1	12	....	11	2	....	2	....	.....	1	....	34	.234
1899	4	.....	.....	2	14	....	10	4	....	1	....	.....	.....	....	35	.251
1900	8	.....	2	....	20	....	10	1	....	2	....	.....	.....	....	43	.298
1901	10	.....	3	2	19	....	9	6	....	2	....	1	.....	2	54	.372
1902	7	.....	1	3	11	....	4	4	....	1	....	.....	.....	.....	31	.209
1903	13	1	1	....	22	....	16	3	....	.....	....	.....	.....	4	60	.399
1904	19	1	2	3	14	....	13	6	....	.....	....	.....	1	11	70	.449
1905	9	.....	2	2	27	....	9	2	....	6	....	.....	2	6	63	.381
1906	19	.....	1	2	34	....	15	.....	1	1	1	.....	1	11	86	.530
1907	5	.....	1	16	31	....	13	7	....	.....	....	2	2	12	89	.532
1908	10	2	1	7	28	....	21	5	....	3	2	.....	1	14	94	.540
1909	9	2	1	3	14	....	15	6	1	3	1	.....	.....	14	69	.414
1910	17	1	.....	2	24	....	26	3	4	1	....	.....	.....	7	85	.502
1911	15	.....	2	6	27	....	18	9	1	4	....	.....	2	4	88	.506
1912	18	1	.....	6	21	....	23	2	.....	3	....	.....	1	5	80	.460
1913	5	.....	1	....	21	....	35	1	2	1	2	.....	.....	7	75	.427
Total.	325	10	25	89	591	....	432	126	9	77	10	3	26	112	1,835	.354
Surface...	7	.....	4	1	8	....	12	.....	.....	.....	.....	.....	.....	13	[b] 45	
Underground.	318	10	21	88	583	....	420	126	9	77	10	3	26	99	1,790	.....

[a] Based on total employees as given in Table 124.
[b] Included in the 2,321 surface fatalities, Table 5.

TABLE 50.—EXPLOSIVES USED IN THE COAL MINES OF PENNSYLVANIA.[a]

Year.	Quantity of explosives used in anthracite mines.			Quantity of explosives used in bituminous mines.		
	Black powder.	Dynamite.	Permissible explosives.	Black powder.	Dynamite.	Permissible explosives.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
1899	34,317,275	3,649,417	.....	6,600,700	222,076	.....
1900	30,929,500	3,454,641	.....	7,469,925	243,517	.....
1901	38,020,100	4,155,685	.....	7,851,500	693,801	.....
1902	21,128,675	2,130,965	.....	9,966,725	921,149	.....
1903	42,529,400	5,317,422	.....	11,145,725	1,135,305	.....
1904	44,779,800	6,519,312	.....	12,626,275	1,320,161	.....
1905	47,570,500	8,353,594	.....	15,194,150	2,159,080	.....
1906	40,352,075	7,980,733	.....	18,119,050	2,425,673	.....
1907	47,636,700	10,544,781	.....	15,874,225	3,425,494	.....
1908	49,380,800	10,766,245	.....	12,738,800	2,193,044	.....
1909	41,191,857	10,724,616	666,827	12,221,214	694,129	3,291,400
1910	45,112,322	11,171,458	1,506,140	12,139,013	513,665	5,126,251
1911	47,846,483	13,369,056	2,122,224	12,925,731	658,330	4,462,416
1912	41,401,015	13,685,062	2,037,026	13,402,034	527,807	5,699,176
1913	44,001,660	16,093,035	3,323,645	14,052,931	696,102	6,715,028

[a] Ann. Rept. Department of Mines of Pennsylvania, 1913, pp. 59, 75.

PERMISSIBLE EXPLOSIVES.

The number of fatalities per 10,000 men employed, due to explosives used in the bituminous coal mines of the United States from

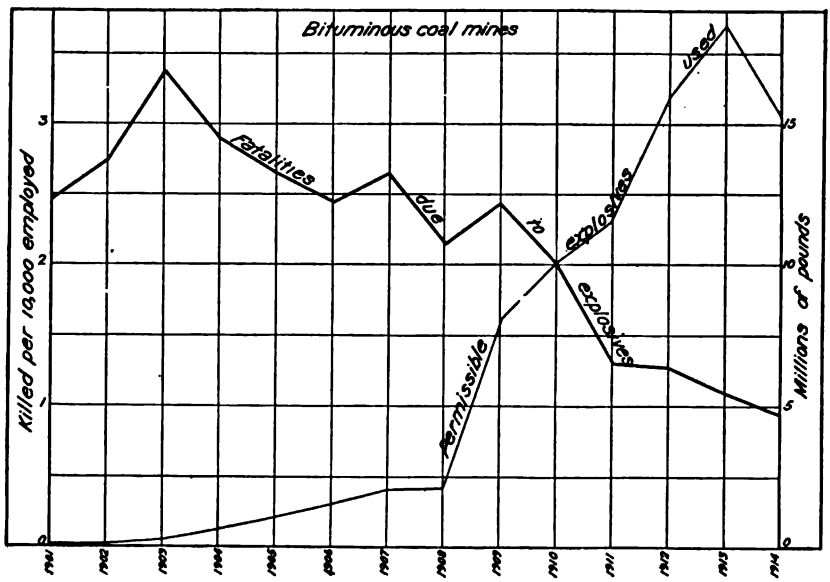


FIGURE 5.—Number of men killed per 10,000 employed, by explosives, in the bituminous coal mines of the United States, compared with the amount of permissible explosives used, 1901–1914. (Based on Table 68.)

1901 to 1914, inclusive, are shown in figure 5. The figure also shows the amount of permissible explosives used for the same period. This period is taken for the reason that in 1901 there were no permissible explosives used in the coal mines of the United States. In 1902 this

class of explosives was introduced, there being 11,300 pounds used during that year. In preparing this chart, the amount of permissible explosives used in the anthracite mines has been eliminated, leaving the figures for bituminous mines only. This chart shows the rapid increase in the use of permissible explosives and, at the same time, a corresponding decrease in the fatality rate. None of the serious mine disasters have been attributed to permissible explosives.

Table 51 shows the amount of black powder, high explosive other than permissible, and permissible explosive used in the coal mines of the United States, geographically grouped, wherein the mining conditions are more or less of a similar character. This table is for the two years 1913 and 1914.

TABLE 51.—QUANTITY OF EXPLOSIVES USED IN THE COAL MINES OF THE UNITED STATES DURING 1913 AND 1914.[a]

States.	Quantity of explosives used.					
	Black blasting powder.[b]		High explosives, other than permissible explosives.		Permissible explosives.	
	1913	1914	1913	1914	1913	1914
	Kegs.	*Kegs.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Maryland and Virginia	124,239	103,250	471,475	286,500	134,000	441,825
Pennsylvania	2,535,098	2,477,542	18,196,494	19,204,406	9,622,475	8,989,625
West Virginia	614,392	566,692	645,425	510,725	3,282,560	2,904,449
Georgia and North Carolina	7,900	5,400	5,680	2,800	.....	.....
Indiana and Kentucky	762,815	764,368	699,201	208,734	482,250	564,525
Illinois	1,269,974	1,195,026	172,300	143,450	1,569,175	1,327,575
Ohio	305,581	192,097	62,300	547,700	6,650	11,200
Alabama and Tennessee	315,942	247,327	722,610	913,775	4,481,975	2,982,363
Michigan	21,421	28,999	20,125	31,900	.....	.....
Iowa, Kansas, and Missouri	875,691	941,702	1,433,550	1,076,450	21,125	15,237
Arkansas, Oklahoma, and Texas	309,390	294,177	455,050	665,770	356,500	396,700
Montana, North Dakota, South Dakota, and Wyoming	161,082	158,270	145,975	154,150	252,625	261,850
Colorado, New Mexico, and Utah	82,416	84,541	615,670	243,760	1,381,950	1,534,900
Alaska, Idaho, Oregon, and Washington	9,940	13,115	473,568	225,825	167,600	163,643
California and Nevada	802	.....	24,650	.....	45,400	.....
Total	7,396,683	7,072,506	24,143,133	24,215,945	21,804,285	19,593,892

[a] Fay, A. H., Production of explosives in the United States during 1914, Tech. Paper 107, 1915, pp. 10–12.
[b] Kegs of 25 pounds each.

QUANTITY OF EXPLOSIVES USED IN THE COAL MINES OF WEST VIRGINIA.[a]

Year.	Number of operators reporting.	Black powder.	Dynamite.	So-called safety powder.
		Kegs.	*Pounds.*	*Pounds.*
1905	395	373,669	.....	.....
1906	409	447,306	.....	.....
1907	460	443,989	.....	.....
1908	498	425,342	788,049	453,074
1909	458	391,282	281,529	1,170,861
1910	580	459,273	303,646	1,661,861
1911	693	409,312	141,209	3,022,682
1912	678	409,540	114,680	3,430,759
1913	698	(b)	(b)	2,010,823

[a] Compiled from State mine inspectors' reports. [b] Not given.

YEARLY SALES OF SHORT-FLAME EXPLOSIVES USED IN COAL MINES IN THE UNITED STATES, 1901–1914.[a]

Year.	Quantity sold.	Year.	Quantity sold.
	Pounds.		*Pounds.*
1901	.....	1908	2,108,610
1902	11,300	1909	8,942,857
1903	288,661	1910	11,820,836
1904	606,270	1911	13,428,239
1905	1,031,300	1912	18,150,618
1906	1,533,575	1913	21,804,285
1907	2,095,244	1914	19,593,892

[a] Fay, A. H., Production of explosives in the United States during 1914: Tech. Paper 107, Bureau of Mines, 1915, p. 13.

QUANTITY OF PERMISSIBLE EXPLOSIVES USED IN DIFFERENT COAL FIELDS IN THE UNITED STATES, 1910–1914.[a]

Coal fields and regions.	1910	1911	1912	1913	1914
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
1. Pennsylvania anthracite field	1,496,100	1,917,412	2,177,172	3,294,225	4,380,635
2. Northern Appalachian region [b]	5,967,216	6,350,272	9,190,025	9,744,810	7,966,464
3. Southern Appalachian region	3,188,785	3,377,268	3,995,485	4,481,975	3,510,013
4. Eastern interior field	165,975	337,012	751,005	2,058,075	1,364,450
5. Western interior field	196,560	255,050	440,825	377,625	411,937
6. Rocky Mountain region	808,200	1,177,075	1,473,129	1,634,575	1,796,750
7. Pacific coast region	8,000	14,150	122,977	213,000	163,643
Total	11,820,836	13,428,239	18,150,618	21,804,285	19,593,892

[a] Fay, A. H., Production of explosives in the United States during 1914: Tech. Paper 107, Bureau of Mines, 1915, p. 13.
[b] Not including Pennsylvania anthracite field.

FALLS OF ROOF.

Table 52 shows the number of fatalities due to falls of roof and pillar coal in and about the coal mines of the United States, by States, during periods ending December 31, 1913, for which continuous records are available. During these various State periods there were 23,011 fatalities due to falls of rock and coal alone. This represents 47.49 per cent of the total number of fatalities, or a fatality rate of 1.57 per 1,000 men employed. (See fig. 3. Pls. I and II.)

It is not always in the mines having the strongest roof where the least number of fatalities occur. When a mine is known to have a bad roof, the miner, foreman, and all others concerned will take special precautions to use plenty of timber to keep the roof in place. Furthermore, the roof will be tested frequently and the miner will be on the lookout at all times when he knows that roof conditions are bad. With a strong roof, however, such precautions are not taken. The miner and the foreman consider the roof safe and give it no further thought. This leads to negligence, and as a result many of the fatalities due to roof falls happen where roof conditions are considered the best.

TABLE 52.—NUMBER OF MEN KILLED BY FALLS OF ROOF AND PILLAR COAL IN THE COAL MINES OF THE UNITED STATES, BY STATES, DURING PERIOD SHOWN ENDED DEC. 31, 1913, FOR WHICH CONTINUOUS RECORDS ARE AVAILABLE.[a]

State.	Number of years in period ended Dec. 31, 1913.	Number killed.		
		Total.	Per cent.	Per 1,000 employed.
Alabama	21	713	38.31	2.01
Arkansas	9	65	60.75	1.46
Colorado	28	852	49.02	3.50
Georgia	5	6	85.71	2.60
Illinois	29	1,616	47.40	1.19
Indiana	19	306	45.07	.97
Iowa	26	426	59.00	1.31
Kansas	21	259	49.05	1.20
Kentucky	26	316	49.76	.98
Maryland	23	127	57.73	1.08
Michigan	14	51	52.04	1.13
Missouri	26	235	62.17	1.10
Montana	14	88	55.34	2.15
New Mexico	21	160	28.17	3.22
North Dakota	6	6	46.16	1.44
Ohio	30	1,509	65.84	1.57
Oklahoma	21	153	20.99	1.14
Oregon	5	1	33.33	.90
Pennsylvania (anthracite)	44	7,378	41.65	1.42
Pennsylvania (bituminous)	36	5,393	56.93	1.64
Tennessee	23	361	42.03	1.81
Texas	5	16	64.00	.67
Utah	22	95	26.76	2.48
Virginia	5	131	52.19	3.33
Washington	25	182	28.44	1.75
West Virginia	29	2,452	51.64	2.57
Wyoming	6	114	47.30	2.46
Total	.....	23,011	47.49	1.57

[a] This table is based on Table 5, and is for periods indicated by States for which continuous records are available. It does not necessarily check with Tables 3 and 4 for the reason that the latter tables include intermittent records prior to the period having continuous records.

Falls of roof form the principal cause of accidents in coal mines, a fact that should command the serious attention of the inspectors, operators, mine foremen, and the miners. Roof falls are bound to happen, yet with proper precautions, use of sufficient timber, and care on the part of the foremen and miners the number of accidents from this cause should be reduced to a considerable extent.

HAULAGE SYSTEMS.

Table 53 shows the number of men killed underground by mine cars and locomotives covering periods for which continuous records are available, including 1913. This class represents one-eighth of the total number of men killed in and about the coal mines, or 0.42 per 1,000 men employed. During the periods covered 6,056 men were killed by mine cars and locomotives. (See fig. 3. Pls. I and II.) This number, however, does not include accidents due to electricity on haulage systems nor injuries inflicted by animals. Details relating to haulage systems of all of the various States are not available, but as an example to show the character of haulage used it has been possible to prepare tables for Illinois, Ohio, West Virginia, and the anthracite and bituminous mines of Pennsylvania.

Table 54 shows the number of horses and mules and steam, electric, and compressed-air locomotives used in the Pennsylvania coal mines from 1898 to 1913. The number of animals used in anthracite haulage has not changed materially during this 15-year period. The number of steam locomotives has practically doubled, the number of electric locomotives has increased from 24 to 781, and the number of compressed-air locomotives has increased from 10 to 161. The number of horses and mules used in bituminous haulage in Pennsylvania has doubled during this period. The number of steam locomotives has increased but slightly, whereas the number of electric locomotives has increased from 122 in 1899 to 1,933 in 1913. The use of compressed-air locomotives has increased in about the same ratio as in the anthracite field, there being 13 in 1899 and 168 in 1913.

TABLE 53.—NUMBER OF MEN KILLED UNDERGROUND BY MINE CARS AND LOCOMOTIVES IN THE COAL MINES OF THE UNITED STATES, BY STATES, DURING PERIOD SHOWN ENDED DEC. 31, 1913, FOR WHICH CONTINUOUS RECORDS ARE AVAILABLE.[a]

State.	Number of years in period ended Dec. 31, 1913.	Number killed.		
		Total.	Per cent.	Per 1,000 employed.
Alabama	21	193	10.37	0.55
Arkansas	9	2	1.87	.05
Colorado	28	141	8.11	.58
Georgia	5			
Illinois	29	414	12.14	.30
Indiana	19	75	11.04	.24
Iowa	26	76	10.53	.23
Kansas	21	12	2.27	.06
Kentucky	26	46	7.25	.14
Maryland	23	30	13.64	.25
Michigan	14	2	2.04	.04
Missouri	26	19	5.03	.09
Montana	14	23	14.47	.56
New Mexico	21	43	7.57	.57
North Dakota	6	2	15.38	.48
Ohio	30	277	12.08	.29
Oklahoma	21	78	10.70	.58
Oregon	5			
Pennsylvania (anthracite)	44	2,403	13.56	.46
Pennsylvania (bituminous)	36	1,452	15.33	.44
Tennessee	23	49	5.70	.25
Texas	5	2	8.00	.08
Utah	22	25	7.04	.65
Virginia	5	32	12.75	.81
Washington	25	81	12.65	.78
West Virginia	29	557	11.73	.58
Wyoming	6	22	9.13	.48
Total		6,056	12.50	.42

[a] This table is based on Table 5 and is for periods indicated, by States, for which continuous records are available. It does not necessarily check with Tables 3 and 4 for the reason that the latter tables include intermittent records prior to the period having continuous records.

In 1900 of the total amount of coal mined in Illinois, 5.5 per cent was transported by electric haulage underground, 10.1 per cent by cable haulage, and 84.4 per cent by horse and mule haulage. In 1912 the electric haulage systems handled 67.7 per cent, the cable haulage 0.7 per cent, and horse and mule haulage 31.6 per cent. In figuring these percentages the amount of coal handled by hand and

TABLE 54.—TYPES OF HAULAGE SYSTEMS, AND NUMBER OF UNITS EMPLOYED IN EACH, IN AND ABOUT THE COAL MINES OF PENNSYLVANIA.[a]

Year.	Anthracite mines.						Bituminous mines.					
	Horses and mules.	Steam locomotives.	Electric locomotives.	Compressed-air locomotives.	Electric dynamos.	Air compressors.[c]	Horses and mules.	Steam locomotives.	Electric locomotives.	Compressed-air locomotives.	Electric dynamos.	Air compressors.[c]
1898	15,910	(b)	24	10	44	99	6,310	(b)	(b)	(b)	(b)	(b)
1899	15,690	352	29	24	45	116	8,013	110	122	13	156	160
1900	15,708	365	38	30	60	139	9,633	119	174	17	196	225
1901	16,059	362	40	51	66	140	10,108	134	231	23	241	255
1902	16,139	373	53	55	70	146	11,833	130	323	16	306	336
1903	16,872	405	84	71	81	166	12,899	162	435	28	391	446
1904	17,085	412	115	88	100	200	12,849	169	560	27	463	503
1905	17,500	454	184	98	117	217	13,710	161	660	31	479	553
1906	16,972	445	223	108	135	237	14,707	162	833	43	535	562
1907	17,125	492	338	111	148	286	15,323	174	1,014	50	623	638
1908	16,837	489	425	144	183	292	14,486	170	966	67	651	631
1909	16,122	529	459	128	196	285	14,722	163	1,169	109	717	625
1910	15,847	552	538	142	233	295	13,741	166	1,358	149	756	671
1911	15,625	573	635	148	249	298	13,774	145	1,438	165	784	653
1912	15,187	575	707	163	255	371	13,908	168	1,617	164	845	641
1913	15,109	607	781	161	261	332	13,868	148	1,933	168	889	620

[a] Compiled from annual reports of the Department of Mines, Harrisburg, Pa. [b] No report. [c] For haulage and other purposes.

TABLE 55.—PERCENTAGE OF COAL HANDLED UNDERGROUND IN ILLINOIS MINES BY ELECTRIC, ROPE, AND ANIMAL HAULAGE WITH FATALITIES DUE TO HAULAGE SYSTEMS.

Year.	Percentage of coal hauled by [a]—			Number of men killed in haulage accidents.	
	Electric haulage.	Rope system.	Animals.	Total.	Per 1,000 employed.
1900	5.5	10.1	84.4	13	0.332
1901	8.1	10.5	81.4	12	.287
1902	8.5	9.7	81.8	16	.337
1903	10.8	8.1	81.1	20	.395
1904	11.3	4.1	84.6	18	.329
1905	12.4	3.8	83.8	21	.362
1906	19.1	4.4	76.5	23	.378
1907	35.9	6.1	58.0	41	.625
1908	40.0	6.7	53.3	27	.397
1909	45.8	2.9	51.3	21	.346
1910	49.5	5.3	45.2	33	.454
1911	60.5	4.7	34.8	43	.568
1912	67.7	.7	31.6	44	.563

[a] Calculated from data published in the State mine inspectors' annual reports.

TABLE 56.—SUMMARY OF THE NUMBER OF MINE LOCOMOTIVES IN WEST VIRGINIA DURING THE FISCAL YEARS ENDING JUNE 30, 1899–1913, INCLUSIVE.[a]

Year.	Number of mines using locomotives.	Number of locomotives in use.				
		Electric.	Steam.	Compressed air.	Gasoline.	Total.
1899	63	24	64	3	.....	91
1900	72	43	69	4	.....	116
1901	96	78	60	3	.....	141
1902	109	107	64	2	.....	173
1903	145	154	74	3	.....	231
1904	168	206	77	6	.....	289
1905	243	253	90	3	.....	346
1906	281	335	83	3	.....	421
1907	333	439	76	4	.....	519
1908	404	590	81	5	.....	676
1909	402	723	78	10	.....	811
1910	483	888	72	7	.....	967
1911	447	921	54	33	.....	1,008
1912	480	1,194	62	38	17	1,311
1913	502	1,365	46	40	28	1,479

[a] Compiled from State mine inspector's annual reports.

other haulage was small and was therefore disregarded. Table 55 shows the percentage of coal handled by the three systems. The fatalities, shown in a parallel column, include in addition to those due to mine cars and locomotives underground, 13 fatalities due to animals and 8 fatalities from electric shock as being attributable to the haulage system. The table shows in general an increasing rate, which is due not so much to electricity as to the more rapid transit and the nearer approach to railroad operations.

Table 56 shows the number of mine locomotives in use in West Virginia from 1899 to 1913. The number of mines using locomotives in 1899 was 63, while in 1913 it was 502. The number of electric locomotives has increased from 24 in 1899 to 1,365 in 1913. The number of steam locomotives has decreased slightly, having dropped

from 64 in 1899 to 46 in 1913. The use of compressed-air locomotives has not increased and in 1912 gasoline locomotives were introduced, 17 being installed in that year and 28 in 1913.

TABLE 57.—MINING MACHINES AND ELECTRIC-HAULAGE MOTORS IN OHIO MINES.[a]

Year.	Mining machines.			Electric-haulage motors.
	Electric.	Compressed air.	Total.	
1889	4	(b)	(b)	1
1890	15	(b)	(b)	2
1891	25	89	114	2
1892	27	102	129	2
1893	41	107	148	2
1894	59	112	171	2
1895	82	82	164	2
1896	130	79	209	6
1897	166	67	233	10
1898	194	58	252	22
1899	236	44	280	28
1900	322	40	362	50
1901	389	40	429	62
1902	527	47	574	96
1903	696	78	774	143
1904	888	87	975	186
1905	1,001	145	1,146	214
1906	1,110	156	1,266	275
1907	1,272	124	1,396	359
1908	1,316	129	1,445	393
1909	1,267	128	1,395	405
1910	1,374	99	1,473	451
1911	1,457	85	1,542	485
1912	1,491	58	1,549	525
1913	1,604	49	1,653	612

[a] Compiled from the annual reports of the State mine inspector. [b] Not reported.

In Table 57 is shown the number of electric haulage motors used in Ohio from 1889 to 1913. In 1889 there was only one electric haulage motor; in 1913 there were 612. The table also shows the increase in the number of electric and compressed-air mining machines.

ACCIDENTS DUE TO ELECTRICITY.

Table 58 shows the number of fatalities by States in and about the coal mines due to electricity since its introduction into the mines. These include both surface and underground fatalities, of which there were 710. The largest percentage of this number of fatalities was due to direct contact with the trolley wire. This group represents practically 50 per cent of the total number of fatalities. The next largest group is that due to contact with machine feed wire, by which 131 were killed, representing 18.45 per cent. The miscellaneous column is unfortunately large, inasmuch as sufficient details were not given in the description of the individual accidents in order to enable a proper classification of these fatalities. Many of them were reported simply as "electrocuted," no details whatever being given; hence this column represents 128 fatalities, or 18 per cent of the total.

TABLE 58.—TOTAL FATALITIES DUE TO ELECTRICITY IN THE COAL MINES IN THE UNITED STATES, BY CAUSES AND STATES.

State.	Period.[a]	Direct contact with trolley wire.							Tool or iron bar striking trolley wire.	Contact with mining machine.	Contact with machine feed wire.	Contact with haulage motor.	Repairing line wires.	Miscellaneous.	Total.
		While climbing on car or motor.	While riding on car or motor.	Replacing trolley pole.	Falling or walking against wire.	Stepping on fallen wire.	Repairing guard boards.	Others.							
Alabama	1905–1913													48	48
Arkansas	1913														
Colorado	1901–1913							9			3			8	20
Georgia	1913														
Illinois	1903–1913	1	3		3	1		7		3	3	1		3	21
Indiana	1903–1913	1						3		1	1			1	7
Iowa	1909–1913													1	1
Kansas	1895–1913									1	1			1	3
Kentucky	1906–1913		2		3			12			1				18
Maryland	1913														
Michigan	1906–1913									2				2	4
Missouri	1912–1913				1					1					2
Montana	1906–1913				1										1
New Mexico	1899–1913										1				1
North Dakota	1913														
Ohio	1896–1913							28	4	2	21		1	7	63
Oklahoma	1898–1913		3							1	2		1	3	10
Oregon	1913														
Pennsylvania (anthracite)	1898–1913	1	2		6	1	2	3	1		4	2	1	11	34
Pennsylvania (bituminous)	1896–1913	34	11	9	75		2	22	34	13	58	1	7	18	284
Tennessee	1903–1913		1					10		1	5				17
Texas	1909–1913													1	1
Utah	1911–1913								1					1	2
Virginia	1909–1913													14	14
Washington	1906–1913	3	1	1	1	1	1	6	3				1		18
West Virginia	1899–1913	8	11	5	4			48	9	3	30	4	3	8	123
Wyoming	1908–1913	1			1						1				3
Total		49	34	15	95	3	5	148	52	28	131	8	14	128	710
Percentage of total		6.90	4.79	2.11	13.38	.42	.70	20.85	7.33	3.94	18.45	1.13	1.97	18.03	100.00

[a] The first date indicates the first recorded fatality due to electricity and not the date of the introduction of electricity into the mines.

TABLE 59.—FATALITIES DUE TO ELECTRICITY IN THE COAL MINES OF GREAT BRITAIN, 1904–1913. [a]

Year.	Ignition of fire damp.	Mine fires.	Fatalities from electric shocks on surface.	Fatalities from electric shocks underground as a result of—							Total fatalities from electric shock.	Grand total.	Shock fatalities according to voltage.					
				Faults as regards grounding of outer coverings of apparatus.			Contact, direct or indirect, with live parts of cables.		Accidental contact with uninsulated live parts of apparatus.	Other causes.			250 volts or less.		250 to 650 volts.		Above 650 volts.	
				Total absence of connection to earth.	Break in continuity of earth connection.	Outer covering grounded, but connection inefficient.	Direct contact due to abrasion of insulation.	Contact with a conductor made live by its contact with cable.					Alternating.	Direct current.	Alternating.	Direct current.	Alternating.	Direct current.
1904	(b)	(b)	.....	.....	.....	.....	.....	.....	.....	7	7	.....	(b)	(b)	(b)	(b)	(b)	(b)
1905	(b)	(b)	2	.....	.....	.....	.....	.....	.....	5	7	.....	1	(b)	(b)	(b)	1	(c)
1906	(b)	(b)	3	.....	.....	.....	.....	.....	2	.....	5	.....	(b)	(b)	1	(b)	2	(c)
1907	(b)	(b)	.....	.....	.....	4	6	.....	.....	.....	10	.....	(b)	(b)	(b)	(b)	(b)	(c)
1908	(b)	(b)	4	.....	.....	.....	6	2	2	1	15	.....	(b)	(b)	(c)	(b)	(b)	(b)
1909	9	1	.....	.....	.....	6	.....	.....	3	4	13	23	5	.....	5	2	1	.....
1910	.....	1	4	1	2	3	1	4	3	2	20	21	2	.....	10	5	3	.....
1911	1	.....	2	2	1	3	.....	3	.....	.....	11	12	1	.....	7	3	.....	.....
1912	3	.....	4	3	.....	1	1	1	1	.....	11	14	.....	.....	8	2	1	.....
1913	.....	.....	3	1	3	3	3	1	2	.....	16	16	2	.....	11	2	1	.....

[a] Great Britain mines and quarries, general report and statistics, pt. 2. [b] Not given. [c] Report states "majority" of fatalities due to this voltage.

In Table 59 is given a classification of accidents due to electricity as compiled from the coal-mine inspectors' reports of Great Britain. The majority of the fatalities were caused by alternating current at voltages ranging from 250 to 650. It is to be expected that the majority of the accidents should be within this range of voltage, as it is used almost exclusively at the mines.

TABLE 60.—NUMBER OF MEN KILLED BY SHAFT ACCIDENTS IN AND ABOUT THE COAL MINES OF THE UNITED STATES, BY STATES, DURING PERIOD SHOWN ENDED DEC. 31, 1913, FOR WHICH CONTINUOUS RECORDS ARE AVAILABLE.[a]

State.	Period ending 1913.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total killed in shafts.	Percentage of total killed.	Number killed per 1,000 employed.
		13	14	15	16			
	Years.							
Alabama	21	5	2	1	.....	8	0.43	0.02
Alaska and California	4	.....	.....	.....	.....	0	.....	.....
Arkansas	9	.....	.....	.....	2	2	1.87	.05
Colorado	28	17	3	14	2	36	2.07	.15
Georgia and North Carolina	5	.....	.....	.....	.....	0	.....	.....
Idaho and Nevada	4	.....	.....	.....	.....	0	.....	.....
Illinois	29	115	28	117	6	266	7.80	.20
Indiana	19	31	2	38	2	71	10.46	.23
Iowa	26	35	6	22	2	65	9.00	.20
Kansas	21	19	6	25	.....	50	9.47	.23
Kentucky	26	10	5	9	.....	24	3.78	.08
Maryland	23	.....	.....	.....	.....	0	.....	.....
Michigan	14	2	2	6	.....	10	10.20	.22
Missouri	26	9	1	17	.....	27	7.14	.13
Montana	14	.....	.....	1	.....	1	.63	.03
New Mexico	21	.....	.....	.....	.....	0	.....	.....
North Dakota	6	.....	.....	.....	.....	0	.....	.....
Ohio	30	33	6	39	1	79	3.45	.08
Oklahoma	21	5	3	14	3	25	3.43	.19
Oregon	5	.....	.....	.....	.....	0	.....	.....
Pennsylvania (anthracite)	44	520	105	211	7	843	4.76	.16
Pennsylvania (bituminous)	36	104	19	90	4	217	2.29	.06
Tennessee	23	1	.....	.....	.....	1	.12	.....
Texas	5	.....	.....	.....	1	1	4.00	.04
Utah	22	2	.....	1	.....	3	.84	.08
Virginia	5	1	.....	.....	.....	1	.40	.03
Washington	25	6	3	2	2	13	2.03	.12
West Virginia	29	43	2	22	.....	67	1.41	.07
Wyoming	6	.....	.....	1	.....	1	.41	.02
Total	.....	958	193	628	32	1,811	3.74	.12

[a] This table is based on Table 5, and is for periods indicated, by States for which continuous records are available. It does not necessarily check with Tables 3 and 4 for the reason that the latter tables include intermittent records prior to the period having continuous records.

MINE SHAFTS.

Table 60 shows the number of fatalities, by States, due to accidents at shafts and subdivided into four different groups, as falling down shafts, objects falling down shafts, cages or skips, and miscellaneous. During the period represented 1,811 were killed by shaft accidents, of which number 843 occurred in and about the anthracite mines. The large number of fatalities at the anthracite mines is not exceptional for the reason that practically all of the mines are opened by

shafts, whereas in the bituminous mines, except some in the Central and Western States, the majority of the mines are opened by slopes and drifts. During 36 years only 217 were killed by reason of shaft accidents at the Pennsylvania bituminous mines, while in Illinois during the 29-year period 266 men were thus killed. The average number of men employed per year in the Pennsylvania bituminous mines is about twice the number employed at the Illinois mines (Table 7), showing that the high Illinois rate, which is more than three times as high as at the bituminous mines of Pennsylvania, is due to the fact that the mines are operated through shafts instead of slopes and drifts. The Illinois mines are more nearly comparable with the anthracite mines in this respect.

More than one-half of all fatalities at shafts are due to persons falling down the shaft, either from the surface or from the various landings. Cages and skips are responsible for slightly over one-third of the shaft accidents. These two causes offer a good field for safety work, and, as shown in Table 4 and figure 1, the accidents at coal-mine shafts are being reduced by reason of vigilance on the part of the inspectors and the installation of safety devices by the operators.

SURFACE SHOPS AND YARDS.

Table 61 shows the number of men killed at surface works about coal mines in the United States during continuous periods as indicated including 1913. The fatalities recorded in this table do not include accidents to coke-oven workers, as these have been eliminated in every case where sufficient information was given to identify the victim with the coking industry. The number of surface fatalities as shown is 3,573, representing 7.37 per cent of the total number killed in and about the mines. The rate per 1,000 men employed is 0.24. Of the total number killed 2,321 were at the surface workings of the anthracite mines and a large percentage of these were killed in the breakers. The accidents in the breakers have been included by reason of the fact that this is one of the branches of the industry which is absolutely necessary to prepare the coal for the market. The coke-oven fatalities of the bituminous field were eliminated for the reason that they are considered foreign to the preparation of the coal for market. It is a second step in which the coal, so to speak, is manufactured into another product.

Almost one-half of the surface fatalities are due to mine cars and locomotives and railway cars and locomotives, thus pointing out the need for closer supervision and better equipment of haulage systems. Boiler explosions and bursting steam pipes are responsible for 214 fatalities. Machinery claimed 775 victims, 629 of which were at the anthracite mines and include many breaker accidents.

TABLE 61.—NUMBER OF MEN KILLED BY SURFACE ACCIDENTS ABOUT THE COAL MINES OF THE UNITED STATES BY STATES, DURING PERIOD SHOWN ENDED DEC. 31, 1913, FOR WHICH CONTINUOUS RECORDS ARE AVAILABLE.[a]

State.	Period ending 1913.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total killed on surface.	Percentage of total killed.	Number killed per 1,000 employed.
		17	18	19	20	21	22			
	Years.									
Alabama	21	.....	.....	11	2	5	10	28	1.50	0.08
Alaska and California	4	.....	.....	.....	.....	.....	.....	0	.....	.....
Arkansas	9	.....	.....	1	.....	.....	.....	1	.94	.02
Colorado	28	21	1	3	3	7	14	49	2.82	.20
Georgia and North Carolina	5	.....	.....	.....	.....	.....	.....	0	.....	.....
Idaho and Nevada	4	.....	.....	.....	.....	.....	.....	0	.....	.....
Illinois	29	5	1	26	15	56	31	134	3.93	.10
Indiana	19	2	.....	.....	1	10	3	16	2.36	.05
Iowa	26	3	.....	.....	6	7	3	19	2.63	.06
Kansas	21	1	.....	2	1	8	5	17	3.22	.08
Kentucky	26	23	.....	2	3	9	10	47	7.40	.15
Maryland	23	12	.....	1	.....	4	5	22	10.00	.19
Michigan	14	.....	.....	.....	2	1	2	5	5.10	.11
Missouri	26	1	.....	1	.....	1	1	4	1.06	.02
Montana	14	.....	.....	3	.....	3	3	9	5.66	.22
New Mexico	21	2	.....	.....	1	.....	1	4	.70	.08
North Dakota	6	.....	.....	.....	.....	.....	.....	0	.....	.....
Ohio	30	22	2	6	18	20	19	87	3.80	.09
Oklahoma	21	4	.....	2	1	1	9	17	2.33	.13
Oregon	5	.....	.....	.....	.....	.....	.....	0	.....	.....
Pennsylvania (anthracite)	44	669	8	629	118	228	669	2,321	13.10	.45
Pennsylvania (bituminous)	36	161	14	57	35	46	92	405	4.28	.12
Tennessee	23	21	.....	1	1	3	7	33	3.84	.16
Texas	5	1	.....	.....	.....	.....	.....	1	4.00	.04
Utah	22	6	1	2	1	3	2	15	4.23	.39
Virginia	5	8	1	.....	.....	3	6	18	7.17	.46
Washington	25	12	.....	9	3	1	10	35	5.47	.33
West Virginia	29	156	13	19	2	28	61	279	5.88	.29
Wyoming	6	3	.....	.....	1	2	1	7	2.91	.15
Total	.....	1,133	41	775	214	446	964	3,573	7.37	.24

[a] This table is based on Table 5, and is for periods indicated, by States for which continuous records are available. It does not necessarily check with Tables 3 and 4, for the reason that the latter tables include intermittent records prior to the period having continuous records.

ACCIDENTS CLASSIFIED BY OCCUPATION.

Data for mine accidents as related to the occupation of the employee are far from complete. Many of the mine inspectors' reports give the occupation of the man who has been fatally injured, and from these reports it is an easy matter to actually compile figures for certain States showing the total number killed in each occupation. However, these reports, with but one or two exceptions, fail to give the actual number of men employed in the specified occupations, and since data of this character are lacking, it is not possible to arrive at any true comparative hazards for the various occupations. The fatality figures may show a larger number of men killed in one occupation, possibly ten times as many, than in some other class of work. At the same time, there may be twenty times as many men engaged in this particular work, so that the hazard would not be as great as indicated by the actual number of men killed. For example, there are rela-

tively few shot firers in the mines as compared with other underground employees, and the actual number of shot firers killed is therefore much smaller than in some other occupations, yet it is an extremely hazardous occupation. To obtain the relative hazard of each occupation the number engaged therein is necessary.

Mine inspectors' reports for the State of Pennsylvania from 1902 to 1913, inclusive, show both the number of men killed in certain of the principal occupations and the corresponding number of men employed therein. Table 62 shows fatalities by occupations in the anthracite mines from 1881 to 1913, inclusive. The corresponding number of men employed, however, is shown only for miners and

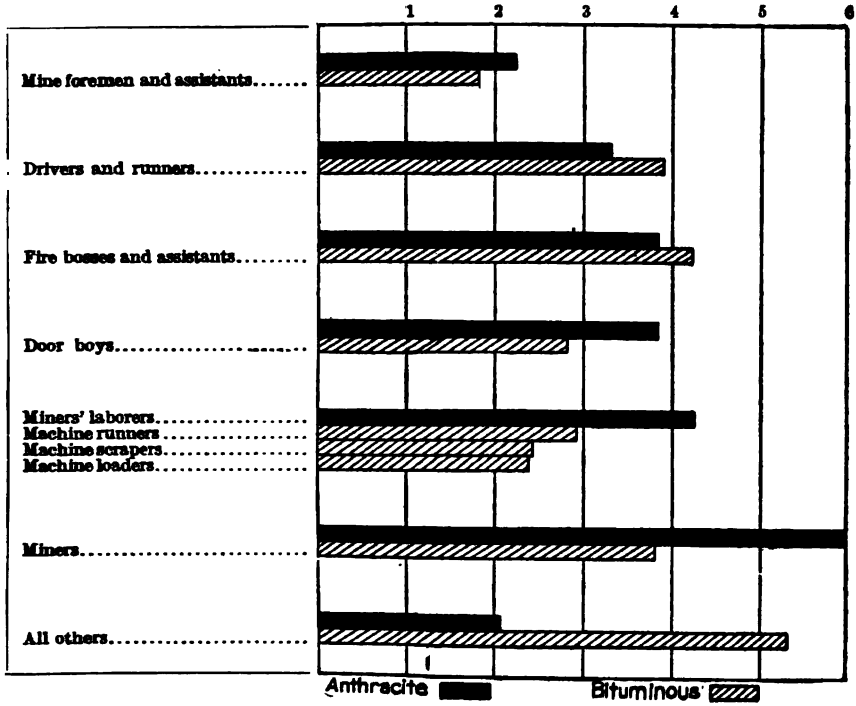


FIGURE 6.—Average number of men killed per thousand employed in anthracite and bituminous mines of Pennsylvania, by occupation, 1902–1913. (Based on Tables 62 and 63.)

miners' laborers. Beginning with 1900 complete figures to and including 1913 are given for the number killed, as well as the number employed in the various occupations. The highest fatality rate is for the anthracite miners, which averages for the period 1900 to 1913, 6 per 1,000 men employed. The fatality rate for the miners' laborers is 4.29 per 1,000 employed. The fatality rate for fire bosses and assistants is 3.86, as compared with 4.29 in the bituminous mines. The rate for mine foremen and assistants is also higher, being 2.28 as against 1.86 in the bituminous mines. The relative occupational hazards for the two periods covered, for both the anthracite and bituminous coal mines of Pennsylvania, are graphically shown in figure 6.

TABLE 62.—NUMBER OF MEN EMPLOYED, NUMBER KILLED PER 1,000 EMPLOYED, BY OCCUPATION, UNDER GROUND, IN THE ANTHRACITE COAL MINES OF PENNSYLVANIA, 1881 TO 1913, INCLUSIVE.[a]

[See fig. 6.]

Year.	Mine foremen and assistants.			Fire bosses and assistants.			Miners.			Miners' laborers.			Drivers and runners.			Door boys, etc.			All other underground employees.		
	Number employed.	Number killed.		Number employed.	Number killed.		Number employed.	Number killed.		Number employed.	Number killed.		Number employed.	Number killed.		Number employed.	Number killed.		Number employed.	Number killed.	
		Total.	Per 1,000 employed.		Total.	Per 1,000 employed.		Total.	Per 1,000 employed.		Total.	Per 1,000 employed.		Total.	Per 1,000 employed.		Total.	Per 1,000 employed.		Total.	Per 1,000 employed.
1881	.....	.....	.....	.....	5	.....	22,809	114	5.00	16,726	70	4.19	.....	28	.....	.....	17	.....	.....	4	.....
1882	.....	3	.....	.....	5	.....	22,843	135	5.91	15,229	56	3.68	.....	28	.....	.....	9	.....	.....	14	.....
1883	.....	2	.....	.....	1	.....	25,319	136	5.37	16,879	67	3.97	.....	47	.....	.....	18	.....	.....	3	.....
1884	.....	1	.....	.....	1	.....	27,100	132	4.87	19,606	81	4.13	.....	28	.....	.....	13	.....	.....	30	.....
1885	.....	.....	.....	.....	3	.....	28,305	160	5.65	20,128	86	4.27	.....	16	.....	.....	6	.....	.....	19	.....
1886	.....	2	.....	.....	2	.....	25,970	131	5.04	17,068	68	3.98	.....	18	.....	.....	6	.....	.....	9	.....
1887	.....	1	.....	.....	5	.....	29,558	102	3.45	17,548	57	3.25	.....	23	.....	.....	10	.....	.....	72	.....
1888	.....	1	.....	.....	2	.....	34,547	169	4.89	21,952	87	3.96	.....	33	.....	.....	9	.....	.....	16	.....
1889	.....	4	.....	.....	2	.....	30,504	194	6.36	19,368	79	4.08	.....	39	.....	.....	10	.....	.....	11	.....
1890	.....	1	.....	.....	5	.....	28,936	146	5.05	18,620	95	5.10	.....	37	.....	.....	8	.....	.....	31	.....
1891	.....	.....	.....	.....	6	.....	30,552	180	5.89	19,590	119	6.07	.....	38	.....	.....	7	.....	.....	22	.....
1892	.....	3	.....	.....	4	.....	30,779	180	5.85	22,110	111	5.02	.....	39	.....	.....	8	.....	.....	16	.....
1893	.....	3	.....	.....	1	.....	32,881	195	5.93	22,853	108	4.73	.....	47	.....	.....	12	.....	.....	22	.....
1894	.....	1	.....	.....	.....	.....	33,357	218	6.54	23,942	91	3.80	.....	38	.....	.....	5	.....	.....	15	.....
1895	.....	5	.....	.....	1	.....	34,553	179	5.18	24,638	115	4.67	.....	33	.....	.....	7	.....	.....	14	.....
1896	.....	3	.....	.....	4	.....	37,003	204	5.51	26,530	134	5.05	.....	46	.....	.....	10	.....	.....	29	.....
1897	.....	3	.....	.....	2	.....	36,932	210	5.69	27,277	99	3.63	.....	26	.....	.....	4	.....	.....	28	.....
1898	485	5	10.31	808	4	4.95	36,377	176	4.84	24,060	124	5.15	10,267	33	3.21	3,072	6	1.95	16,103	12	0.75
1899	.....	2	.....	.....	2	.....	36,421	199	5.46	23,946	114	4.76	.....	39	.....	.....	18	.....	.....	15	.....
1900	519	.....	.....	808	5	6.19	36,332	184	5.00	24,613	95	3.86	10,177	33	3.24	3,128	8	2.56	18,063	33	1.83
1901	539	5	9.28	830	2	2.41	37,804	224	5.93	26,265	122	4.64	10,894	45	4.13	3,148	6	1.91	18,951	37	1.95
1902	648	2	3.09	824	3	3.64	36,392	114	3.13	25,443	62	2.44	10,595	27	2.55	3,308	5	1.51	21,102	32	1.52
1903	666	3	4.50	841	2	2.38	36,823	204	5.54	27,533	110	4.00	11,251	46	4.09	3,087	12	3.89	21,854	51	2.33
1904	703	3	4.27	901	1	1.11	39,848	233	5.85	31,217	145	4.64	11,607	31	2.67	3,173	20	6.30	22,913	63	2.75
1905	734	1	1.36	932	2	2.15	42,078	308	7.32	31,967	148	4.63	12,069	31	2.57	3,284	14	4.26	25,307	47	1.86
1906	749	2	2.67	983	6	6.10	41,801	226	5.41	29,652	133	4.49	11,889	32	2.69	2,919	9	3.08	27,005	48	1.78
1907	868	2	2.30	917	2	2.18	43,035	309	7.18	29,984	136	4.54	11,810	46	3.90	2,711	18	6.64	28,524	88	3.09
1908	1,180	3	2.54	658	3	4.56	44,340	313	7.06	32,853	154	4.69	11,968	49	4.09	2,970	18	6.06	30,264	56	1.85
1909	1,208	1	.83	684	2	2.92	44,675	264	5.91	32,232	126	3.91	11,960	37	3.09	3,026	11	3.64	29,492	49	1.66
1910	1,252	2	1.60	707	2	2.83	43,651	254	5.82	32,040	147	4.59	11,589	40	3.45	2,432	6	2.47	29,871	58	1.94

1911	1,301	2	1.54	762	5	6.56	45,324	306	6.75	32,905	176	5.35	11,656	45	3.86	2,421	15	6.20	31,668	66	2.09
1912	1,299	1	.77	783	1	1.26	44,696	262	5.86	33,438	117	3.50	11,479	42	3.66	2,449	8	3.27	33,664	67	1.99
1913	1,510	3	1.99	778	8	10.28	44,346	286	6.45	33,973	148	4.36	11,463	33	2.88	2,611	7	2.68	33,986	72	2.12
Total (1900–1913)	13,171	30	2.28	11,407	44	3.86	551,645	3,487	6.00	494,115	1,819	4.29	160,407	537	3.35	40,667	157	3.86	372,664	767	2.06

[a] Compiled from annual reports of the Department of Mines, Harrisburg, Pa.

TABLE 63.—NUMBER OF MEN EMPLOYED AND NUMBER KILLED, CLASSIFIED BY OCCUPATION, IN THE BITUMINOUS MINES OF PENNSYLVANIA, 1902 TO 1913.[a]

[See fig. 6.]

Year.	Mine foremen and assistants.			Fire bosses and assistants.			Miners.			Machine runners.			Machine loaders.			Machine scrapers.			Drivers and runners.			Door boys and helpers.			All others.		
	Number employed.	Number killed.		Number employed.	Number killed.		Number employed.	Number killed.		Number employed.	Number killed.		Number employed.	Number killed.		Number employed.	Number killed.		Number employed.	Number killed.		Number employed.	Number killed.		Number employed.	Number killed.	
		Total.	Per 1,000 employed.		Total.	Per 1,000 employed.		Total.	Per 1,000 employed.		Total.	Per 1,000 employed.		Total.	Per 1,000 employed.		Total.	Per 1,000 employed.		Total.	Per 1,000 employed.		Total.	Per 1,000 employed.		Total.	Per 1,000 employed.
1902	1,197	4	3.34	427	7	16.39	59,025	314	5.32	2,940	13	4.42	25,796	35	1.36	2,942	10	3.40	8,061	23	2.85	1,893	2	1.06	7,679	34	4.43
1903	1,327	1	.75	494	3	6.07	66,086	236	3.57	3,276	10	3.05	29,479	48	1.63	3,013	5	1.66	8,768	39	4.45	1,872	5	2.67	9,639	28	2.90
1904	1,307	1	.77	555	2	3.60	62,248	208	3.34	3,717	16	4.30	38,344	143	3.73	3,461	12	3.47	8,544	26	3.04	1,712	6	3.50	9,635	98	10.17
1905	1,372	2	1.46	591	5	8.46	66,814	261	3.91	3,816	13	3.41	38,156	77	2.02	3,671	7	1.91	9,421	38	4.03	1,831	2	1.64	10,218	38	3.72
1906	1,475	3	2.03	654	4	6.12	69,316	247	3.56	4,109	7	1.70	38,582	105	2.72	3,865	13	3.36	9,858	37	3.75	2,026	3	1.48	11,977	36	3.01
1907	1,556	2	1.29	741	8	10.80	72,169	362	5.02	4,191	19	4.53	40,879	172	4.21	4,001	8	2.00	10,649	79	7.42	2,172	22	10.13	14,013	94	6.71
1908	1,455	3	2.06	803	4	4.98	72,329	219	3.03	4,132	11	2.66	44,841	144	3.21	3,847	8	2.08	9,712	33	3.40	2,011	2	.99	13,406	126	9.40
1909	1,496	4	2.67	917	1	1.09	73,669	260	3.53	4,217	11	2.61	41,976	69	1.64	4,022	6	1.49	10,046	37	3.68	1,945	5	2.57	14,126	82	5.80
1910	1,541	3	1.95	1,036	1	.97	73,771	235	3.19	4,502	7	1.55	46,696	119	2.55	4,160	7	1.68	10,256	41	4.00	1,808	6	3.16	15,811	65	4.11
1911	1,813	0	.....	937	1	1.07	66,864	267	3.99	4,326	12	2.77	47,120	104	2.21	4,185	11	2.63	9,719	31	3.19	1,577	3	1.90	15,245	61	4.00
1912	2,086	4	1.96	968	2	2.07	60,964	215	3.53	4,315	7	1.62	47,660	43	.90	4,188	12	2.87	10,072	34	3.38	1,527	2	1.31	17,211	88	5.11
1913	2,220	8	3.60	975	1	1.03	59,986	254	4.23	4,606	15	3.26	54,026	134	2.48	4,312	13	3.01	10,659	41	3.85	1,867	4	2.88	18,101	91	5.03
Total	18,796	35	1.86	9,098	39	4.29	808,241	3,078	3.83	48,149	141	2.93	493,555	1,193	2.42	45,867	112	2.45	115,765	459	3.96	21,851	63	2.88	157,971	841	5.35

[a] Compiled from annual reports of the Department of Mines, Harrisburg, Pa.

Table 63 shows the number of men employed and number killed, classified by occupations, in the bituminous mines of Pennsylvania from 1902 to 1913, inclusive. During the 12-year period the fatality rate for miscellaneous employees was 5.35 per 1,000 men employed; fire bosses, 4.29; drivers and runners, 3.96; and miners, 3.83.

NONFATAL INJURIES IN COAL MINES IN THE UNITED STATES.

There are no complete records of the nonfatal injuries at the coal mines in the United States. In 1911 the bureau collected direct from the operators statistics relating to nonfatal injuries for that year. The number of serious [a] injuries reported was 9,106 and of slight injuries, 22,228. These reports were doubtless incomplete, as many of the mining companies were not keeping complete records of all accidents at their mines. Furthermore, there were but few compensation laws in effect which compelled the operators to keep records of nonfatal injuries.

The number killed per 1,000 employed in the metal mines is less than in the coal mines when compared on an equal time basis of 300-day workers. In view of this fact there is no reason to believe that the number of nonfatal injuries should be less in the coal mines than in the metal mines.

The best figures available on this subject are those collected by the United States Bureau of Mines for the metal-mining industry. The bureau has issued reports covering a period of four years, 1911 to 1914, in which the number of nonfatal accidents reported represent about 30 per 1,000 wherein the injured person was off duty 20 days or more by reason of disability. The bureau's reports show that approximately 150 men per 1,000 received minor injuries resulting in a disability varying from 1 to 20 days. These figures are based upon voluntary reports of the mining companies to the Bureau of Mines. Since there is no Federal law requiring these reports, it is believed that the above rates are too low. This view is supported by a special study of metal-mine accidents for 1914, which contains the reports of 258 companies whose accident records are reasonably complete. The study shows that 50 per 1,000 are seriously injured (disabled 20 days or more), while 270 per 1,000 are slightly injured (disabled 1 to 20 days). These injuries, however, apply only to, and are based on, 75,000 men employed either underground or in the open-pit mines, excluding all surface, shop, and mill men. Taking the average metal-mine rate for a period of four years as a basis of injuries in the coal mines, there would be approximately 22,900 persons seriously injured and 114,500 persons slightly injured each year.

[a] Serious injuries include those causing a loss of time of 20 days or more. A slight injury is one causing a loss of more than one day but less than 20.

In 1911 two-thirds of the serious and slight injuries in the coal mines were due to falls of roof and pillar coal and mine cars and locomotives. About one-half of the nonfatal injuries in the metal mines were due to these two causes, showing that there are more injuries in the coal mines from them than in the metal mines. The coal mines have a much larger area of roof exposed than do the metal mines, and in most cases the haulage system is more extensive by reason of the longer haul and the excess tonnage handled, thus increasing the coal-mine hazard as compared with metal mines. These being the principal causes of nonfatal injuries, there seems reason to believe that the above estimate is too low rather than too high.

Tables 64, 65, and 66 show the injuries as reported by the State mine inspectors in their latest published reports for the States indicated. These tables represent 6,719 injuries, which have been classified according to the part of the body injured, and also by causes. The accidents are also tabulated by States with reference to the part of the body injured and the cause of the injury. These tables are far from being complete, inasmuch as they represent only the more serious injuries. For example, the report for Illinois includes only those accidents in which the injury resulted in a loss of 30 days' time or more. In some of the States no time is specified and no statement given to indicate what class of injuries is included in the report.

These tables will be of some assistance to the hospital department of the various coal mines, inasmuch as they point out the part of the body receiving the most injuries and will give the surgeons and others an idea as to the surgical equipment necessary to properly take care of the injuries to be expected in and about the coal mines.

NUMBER AND PERCENTAGE OF INJURIES RECEIVED BY MEN EMPLOYED IN AND ABOUT COAL MINES, BY PARTS INJURED.

[See also fig. 7.]

	Number.	Percentage.
Head	427	6.36
Face	290	4.32
Shoulders	330	4.91
Arms	544	8.10
Hands	948	14.11
Body	1,190	17.71
Hip and pelvis	281	4.18
Legs	1,987	29.57
Feet	722	10.74
Total	6,719	100.00

With the enactment of compensation laws in the various States, it is hoped that in the near future there will be more complete data available to afford a basis for a detailed study of nonfatal injuries.

However, sufficient data concerning fatal injuries have been collected and tabulated herein to form a basis for an intensive study of the various accidents by causes. Any safety device, rule, regulation, law, or instruction to miners that will reduce fatal accidents will also reduce the nonfatal accidents. The difference between the two

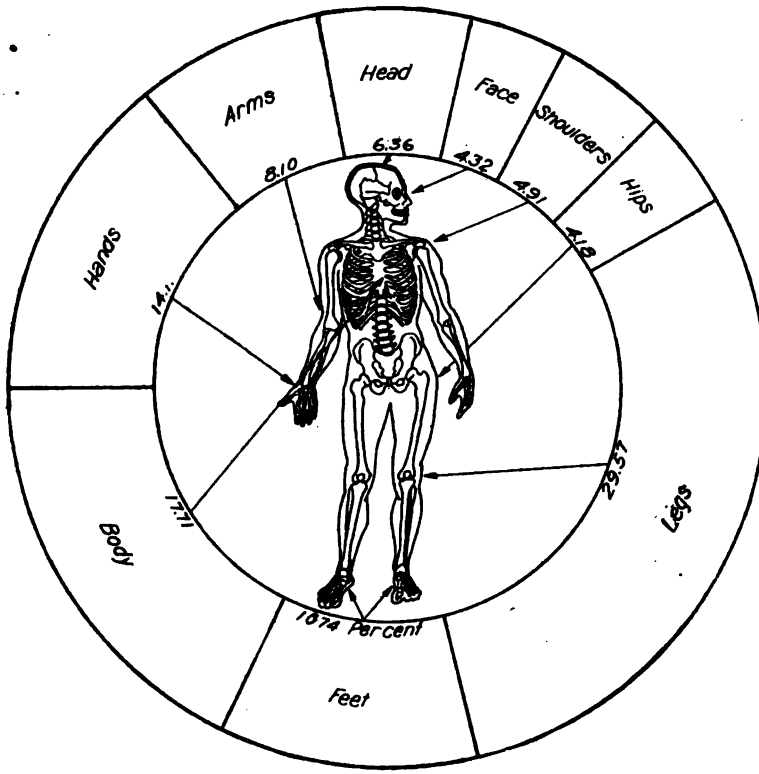


FIGURE 7.—Analysis of nonfatal injuries showing part of body injured and percentage for each location. (Based on Table 66.)

classes of accidents is only one of degree or severity. The cause still remains the same: fall of rock, mine car, or explosive. If a falling rock strikes a man on the head or body it may kill him, but if it strikes only his foot or hand, seriously injuring him, the cause, fall of rock, is the same. By removing the cause of fatal accidents, the number of nonfatal accidents will be greatly reduced.

TABLE 64.—NUMBER AND CAUSES OF NONFATAL INJURIES IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING 1913 OR NEAREST YEAR FOR WHICH RECORDS ARE AVAILABLE, BY STATES.[a]

[Data not available for States not listed.]

State.	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Falls of persons.	Falling objects (other than a and b).	Flying objects.	Rush of coal or gob in chute or bin.	Hand tools.	Machinery.	Ropes and cables.	Cages or skips.	Boilers and steam pipes.	Lifting (strains).	Timber.	Railroad cars.	Nails and splinters.	Running into or against objects.	Explosions of oil or gasoline.	Total.
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	
Arkansas	32	2	30	13	....	4	....	....	2	4	....	4	5	....	....	2	1	....	....	....	2	1	....	....	....	....	102
Illinois	145	144	161	11	....	9	....	2	22	18	....	22	13	21	....	14	4	....	13	2	13	28	....	1	4	....	647
Indiana	112	28	145	12	....	29	....	1	32	14	....	6	2	3	....	5	....	1	6	3	....	4	1	....	1	1	422
Iowa	67	18	52	....	....	3	....	....	10	2	....	3	3	....	....	....	1	....	2	....	....	2	....	....	1	....	102
Kansas	120	19	140	28	....	17	3	....	5	....	....	6	3	8	....	2	3	....	3	....	7	4	....	1	....	....	369
Maryland	46	15	48	....	....	1	....	....	4	....	....	5	3	....	....	7	2	....	1	....	7	4	....	1	....	....	144
Missouri	36	7	19	1	....	....	....	....	4	1	....	....	....	....	....	1	....	....	....	....	....	1	....	....	....	....	70
Montana	30	17	38	....	....	4	....	....	....	1	....	....	1	....	....	1	....	....	....	....	....	2	1	....	....	....	96
North Dakota	2	7	3	....	....	8	....	....	....	....	....	....	....	1	....	1	....	....	3	....	....	....	....	....	....	....	21
Ohio	240	45	173	5	....	13	....	4	10	47	....	5	2	3	....	8	8	....	1	3	....	6	1	....	4	....	578
Oklahoma	27	4	26	6	....	2	....	....	3	3	....	....	....	1	....	1	....	....	3	2	1	1	....	....	....	....	88
Pennsylvania (anthracite)	262	104	296	88	....	95	....	2	26	2	....	37	10	5	....	9	23	....	6	8	....	32	8	....	2	....	1,015
Pennsylvania (bituminous)	419	158	339	4	1	48	....	2	14	38	....	14	7	2	....	2	15	....	3	3	....	2	3	....	....	2	1,076
Texas	1	7	20	1	....	1	....	....	3	....	....	3	....	1	....	2	1	....	2	....	1	1	....	3	....	....	47
Utah	7	4	24	....	....	1	....	....	1	4	....	3	....	1	....	1	....	....	....	3	....	1	....	....	....	....	50
Virginia	81	25	114	2	....	6	....	18	3	2	....	8	13	3	....	19	22	....	....	....	1	16	....	12	2	....	347
Washington	225	89	124	28	2	8	....	4	7	....	....	56	12	59	11	70	12	15	2	2	32	52	3	13	2	2	330
West Virginia	243	72	240	6	....	32	....	1	7	31	....	9	5	....	....	4	6	1	1	....	1	2	6	1	....	1	669
Total	2,095	765	1,992	205	3	281	3	34	153	167	....	181	79	106	11	149	96	17	51	26	65	159	23	32	16	6	6,719

[a] Compiled from State mine inspector's reports. These figures represent only the more serious injuries, the minimum range of disability being 7 to 30 days. They are not uniform for the various States, simply being all that were published in the various inspectors' reports during a period of one year.

TABLE 65.—NUMBER OF NONFATAL INJURIES, SHOWING PARTS OF BODY INJURED, IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING 1913 OR NEAREST YEAR FOR WHICH RECORDS ARE AVAILABLE, BY STATES.[a]

[Data not available for States not listed.]

Part of body injured.	Arkansas.	Illinois.	Indiana.	Iowa.	Kansas.	Maryland.	Missouri.	Montana.	North Dakota.	Ohio.	Oklahoma.	Pennsylvania (anthracite).	Pennsylvania (bituminous).	Texas.	Utah.	Virginia.	Washington.	West Virginia.	Total.
Head injured	13	36	20	6	15	6	5	4	3	49	9	100	48	3	3	29	49	29	427
Face burned	2	3	10	.....	12	.....	.....	1	.....	4	2	26	7	.....	.....	5	15	7	84
Eye injured	.....	12	3	.....	17	.....	1	.....	.....	5	1	4	2	1	.....	13	60	2	121
lost	.....	7	3	.....	.....	.....	.....	.....	1	.....	1	2	2	.....	.....	.....	.....	3	19
Eyes injured	1	1	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	.....	1	1	.....	2	10
lost	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	.....	.....	.....	.....	1	5
Nose broken	1	1	1	2	.....	.....	.....	.....	.....	.....	1	4	5	.....	.....	.....	2	1	18
Jaw broken	.....	3	1	2	.....	.....	.....	.....	.....	1	.....	6	4	.....	.....	.....	.....	6	23
Collar bone broken	.....	15	12	8	1	1	2	3	.....	9	1	16	48	1	3	.....	3	16	139
Arm injured	5	11	10	1	9	4	.....	1	.....	8	1	12	8	1	.....	16	22	6	115
burned	2	2	6	.....	6	.....	.....	.....	.....	1	1	14	4	.....	.....	3	5	3	47
broken	3	19	27	9	3	4	1	4	.....	17	.....	82	63	4	3	4	3	37	283
lost	.....	1	1	.....	.....	.....	.....	.....	.....	2	.....	1	6	.....	.....	.....	.....	3	14
Arms injured	1	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	3
broken	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	9	.....	.....	.....	.....	1	11
lost	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0
Wrist injured	1	6	.....	.....	3	.....	1	.....	.....	2	1	2	.....	.....	.....	5	9	4	34
broken	.....	3	3	1	2	.....	.....	.....	.....	3	.....	10	9	.....	1	3	.....	2	37
Hand injured	3	16	9	3	29	14	1	3	1	24	4	16	16	.....	4	19	74	5	241
burned	5	5	16	1	19	.....	1	1	.....	4	3	41	12	.....	.....	8	17	10	143
broken	.....	6	3	1	.....	.....	.....	1	.....	1	.....	2	.....	.....	.....	2	1	3	20
lost	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....	4	4	.....	1	.....	.....	2	13
Hands injured	.....	1	1	1	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	4	.....	9
broken	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0
lost	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	1
Thumb injured	1	13	4	1	8	2	.....	.....	.....	4	.....	.....	1	.....	.....	4	32	.....	70
broken	.....	.....	1	.....	.....	1	.....	.....	.....	.....	.....	.....	1	.....	.....	2	4	.....	9
lost	.....	3	3	1	.....	.....	.....	1	.....	3	.....	1	4	.....	.....	.....	1	2	19
Finger injured	.....	28	6	.....	42	8	2	1	.....	22	5	7	.....	.....	2	27	55	.....	208
broken	.....	6	.....	3	1	3	1	.....	.....	1	.....	4	1	1	.....	2	13	2	38
lost	.....	12	15	4	3	1	.....	.....	.....	4	1	8	15	1	.....	1	2	11	78
Fingers injured	6	4	5	1	4	3	.....	.....	.....	6	.....	3	3	.....	.....	6	9	2	58
broken	.....	1	2	.....	1	.....	.....	.....	.....	1	.....	2	4	.....	.....	2	1	1	15
lost	.....	1	2	2	.....	.....	.....	.....	.....	3	.....	6	12	.....	.....	1	2	6	35

Shoulder injured	4	15	11	5	7	4	4	2	.....	27	1	7	10	.....	.....	11	32	11	131
broken	.....	5	3	1	.....	.....	.....	.....	1	2	.....	11	14	.....	.....	1	.....	2	40
Body injured	6	53	9	5	5	3	6	5	12	24	8	39	44	5	1	10	43	19	267
burned	4	4	8	1	2	.....	.....	2	.....	1	1	24	4	2	2	3	1	4	61
Rib broken	1	7	13	5	1	1	2	.....	.....	6	2	12	13	2	1	2	8	7	83
Ribs broken	3	9	16	8	2	8	5	3	.....	12	4	40	33	1	2	1	10	19	170
Back injured	10	52	23	6	38	19	8	2	.....	47	11	45	42	2	3	21	76	48	455
broken	1	4	2	1	1	1	2	1	.....	1	.....	8	17	1	1	1	.....	11	53
Hip or hips injured	4	21	24	9	3	2	6	5	.....	36	2	23	27	1	.....	13	19	26	221
broken	.....	.....	3	3	.....	.....	2	.....	1	2	.....	3	5	1	.....	1	2	3	26
Pelvis broken	.....	4	.....	1	.....	.....	.....	.....	.....	1	.....	9	8	.....	.....	1	2	8	34
Leg injured	8	49	21	14	33	15	6	7	.....	59	8	27	47	1	.....	20	69	18	408
burned	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	.....	.....	1	.....	.....	3
broken	3	67	53	28	8	6	5	26	1	62	7	285	357	6	9	16	14	196	1,149
lost	.....	2	.....	.....	.....	.....	.....	.....	.....	2	.....	2	3	.....	1	1	.....	7	18
Legs injured	.....	4	1	2	.....	2	.....	1	.....	5	.....	.....	5	2	1	1	3	.....	27
broken	.....	.....	.....	1	.....	.....	.....	3	.....	3	1	12	16	.....	.....	.....	1	4	41
lost	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1
Knee injured	.....	11	3	2	20	.....	.....	4	.....	6	1	4	3	.....	1	7	34	5	101
Foot injured	8	50	23	10	39	22	4	8	2	63	4	24	34	9	4	60	73	34	471
broken	1	21	11	4	2	.....	1	3	.....	5	.....	8	13	.....	.....	1	2	12	84
lost	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	3	7	.....	.....	.....	.....	10	21
Feet injured	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	1	4	9
broken	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	●
lost	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	●
Ankle injured	3	19	9	4	22	3	1	2	.....	22	1	6	16	.....	1	10	32	7	159
broken	.....	8	3	2	.....	1	1	.....	3	2	.....	19	26	1	2	.....	1	18	87
Ankles injured	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	●
broken	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	●
Toe injured	.....	4	.....	1	3	2	.....	.....	.....	5	1	2	5	1	1	6	10	1	42
broken	.....	7	.....	1	2	.....	.....	.....	.....	1	.....	3	5	.....	.....	2	5	2	26
lost	1	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	2	3	.....	.....	1	.....	6	14
Toes injured	.....	7	1	.....	1	1	1	.....	.....	2	1	1	7	.....	2	.....	2	1	27
broken	.....	2	1	1	.....	3	1	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	2	12
lost	.....	1	.....	1	.....	.....	.....	1	.....	.....	.....	.....	5	.....	.....	1	.....	4	12
Internal injuries	1	.....	2	1	2	.....	.....	.....	.....	5	1	12	13	.....	.....	1	4	10	52
Rupture (hernia)	.....	2	1	.....	2	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	2	13
Total	102	647	406	164	369	144	70	95	25	578	85	1,015	1,076	47	50	347	830	669	6,719

[a] See footnote, Table 64.

TABLE 66.—NUMBER AND CAUSES OF NONFATAL INJURIES, SHOWING PARTS OF BODY INJURED, IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING 1913 OR NEAREST YEAR FOR WHICH RECORDS ARE AVAILABLE.[a]

Part of body injured.	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Falls of persons.	Falling objects (other than a and b).	Flying objects.	Rush of coal or gob in chute or bin.	Hand tools.	Machinery.	Ropes and cables.	Cages or skips.	Boilers and steam pipes.	Lifting (strains).	Timber.	Railroad cars.	Nails and splinters.	Running into or against objects.	Explosions of oil or gasoline.	Total.
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	
Head injured	179	37	52	4	....	55	3	....	20	2	....	17	3	5	1	4	7	1	4	3	....	19	2	....	4	....	357
Face burned	....	....	....	54	1	28	....	7	....	....	....	....	....	....	....	....	....	....	....	2	....	....	....	....	....	2	96
Eye injured	16	5	1	....	....	4	....	1	3	....	....	....	1	32	....	2	1	....	....	....	....	3	....	....	1	1	121
lost	1	....	....	....	....	7	....	....	....	....	....	....	....	3	....	3	....	....	....	....	....	....	....	....	....	....	19
Eyes injured	....	....	....	....	....	3	....	1	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	10
lost	....	....	....	....	....	3	....	....	....	....	....	....	....	2	....	....	....	....	....	....	....	....	....	....	....	....	5
Nose broken	8	1	1	....	....	1	....	....	2	1	....	....	....	....	....	....	....	....	....	....	....	4	....	....	....	....	18
Jaw broken	5	....	7	....	....	3	....	....	4	....	....	1	....	2	....	1	....	....	....	....	....	....	....	....	....	....	23
Collar bone broken	25	31	64	1	....	....	....	....	5	1	....	2	2	....	....	....	1	....	....	....	....	4	....	....	3	....	129
Arm injured	30	12	34	....	....	4	....	....	5	2	....	4	....	1	....	6	7	....	1	....	1	6	....	1	1	....	115
burned	....	....	....	27	....	15	....	4	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	....	....	27
broken	87	27	95	....	....	8	....	....	12	6	....	23	4	....	....	2	9	....	2	1	....	6	1	....	....	....	223
lost	3	1	5	....	....	2	....	....	....	....	....	....	....	....	....	....	3	....	....	....	....	....	....	....	....	....	14
Arms injured	2	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	3
broken	3	....	6	....	....	1	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	11
lost	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	6
Wrist injured	7	2	12	....	....	....	....	....	....	....	....	4	....	....	....	7	....	....	....	....	1	....	....	....	1	....	34
broken	6	4	14	....	....	....	....	....	4	....	....	5	....	....	....	....	....	....	2	....	....	2	....	....	....	....	37
Hand injured	51	16	99	....	....	7	....	1	1	6	....	3	5	2	1	25	9	2	1	....	....	8	1	3	....	....	241
burned	....	....	....	80	2	44	....	12	....	....	....	....	....	....	....	....	....	....	....	4	....	....	....	....	....	....	162
broken	5	1	3	....	....	1	....	....	2	1	....	1	3	1	....	....	1	....	....	....	....	1	....	....	....	1	26
lost	1	1	4	....	....	7	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	13
Hands injured	1	....	3	1	....	1	....	....	....	....	....	....	....	....	....	1	....	1	....	....	....	....	....	1	....	....	8
broken	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1
lost	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1

Thumb injured	15	8	19	....	....	1	....	....	....	....	....	....	1	....	1	15	4	1	....	....	4	....	1	....	....	
broken	1	....	5	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	1	....	1	....	....	....	....	
lost	1	1	9	....	....	2	....	....	....	1	....	....	....	....	....	2	2	....	....	....	....	1	....	....	....	
Finger injured	35	21	92	....	....	....	....	2	7	....	....	3	....	....	21	7	3	....	....	....	10	1	2	1	....	
broken	10	7	10	....	....	....	....	....	2	....	....	1	....	....	3	1	....	....	....	....	4	....	....	....	....	
lost	9	4	40	....	....	3	....	1	5	....	....	2	....	....	4	6	2	....	....	....	2	....	....	....	....	
Fingers injured	1	4	31	....	....	....	....	....	6	....	....	1	1	....	2	2	1	....	....	1	....	....	2	....	....	
broken	2	....	8	....	....	....	....	....	1	....	....	....	....	....	1	2	....	1	....	....	....	....	....	....	....	
lost	2	1	15	....	....	5	....	....	4	....	....	....	....	....	....	6	....	....	....	....	1	....	....	....	1	
Shoulder injured	63	16	45	....	....	2	....	4	....	....	6	1	....	2	1	....	....	1	....	....	8	1	....	1	....	
broken	9	9	18	....	....	1	....	1	....	....	....	....	....	....	....	....	....	1	1	....	....	....	....	....	....	
Body injured	79	35	109	....	....	13	....	17	4	....	10	3	....	....	2	4	....	2	1	6	5	3	....	....	....	
burned	....	....	....	36	....	18	....	....	1	....	....	....	....	....	....	....	....	....	4	....	....	....	....	....	1	
Rib broken	37	6	24	....	....	1	....	4	1	....	7	....	....	....	....	1	....	....	....	....	2	....	....	....	....	
Ribs broken	64	14	66	....	....	2	....	7	....	....	11	1	....	....	3	2	....	2	....	....	4	....	....	....	....	
Back injured	249	47	71	....	....	4	....	3	4	....	15	4	....	3	....	....	....	5	1	42	5	....	....	....	....	
broken	42	6	4	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
Hip or hips injured	82	14	95	....	....	....	....	9	2	....	6	1	....	....	....	1	....	3	....	2	4	1	....	1	....	
broken	13	3	7	....	....	....	....	....	....	....	2	....	....	....	....	1	....	....	....	....	....	....	....	....	....	
Pelvis broken	12	6	13	....	....	1	....	1	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	
Leg injured	109	58	157	....	....	6	....	18	13	....	7	4	....	2	9	3	3	1	2	....	10	....	....	....	....	
burned	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	1	....	....	1	....	....	....	....	....	....	
broken	474	212	327	1	....	17	....	14	26	....	26	7	....	....	3	6	1	5	4	....	20	5	....	1	....	1,169
lost	2	2	7	....	....	....	....	....	4	....	....	....	....	....	....	1	....	....	....	....	....	2	....	....	....	
Legs injured	4	3	15	....	....	1	....	....	1	....	....	....	....	....	....	....	....	1	....	....	....	1	....	1	....	
broken	18	8	13	....	....	1	....	....	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	
lost	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
Knee injured	30	18	26	....	....	1	....	2	1	....	11	....	1	....	3	....	1	2	....	1	....	....	3	1	....	
Foot injured	123	57	172	....	....	....	....	6	28	....	7	14	....	....	22	4	1	5	....	....	11	2	19	....	....	
broken	32	11	31	....	....	1	....	....	4	....	1	2	....	....	1	....	....	....	....	....	....	1	....	....	....	
lost	6	....	9	....	....	....	....	....	6	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
Feet injured	4	1	2	....	....	....	....	....	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
broken	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
lost	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
Ankle injured	40	25	70	....	....	....	....	....	1	....	8	1	2	....	2	2	....	1	1	....	5	....	....	....	....	155
broken	35	15	21	....	....	....	....	2	4	....	1	1	....	....	....	....	....	4	....	....	4	....	....	....	....	37
Ankles injured	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
broken	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
Toe injured	12	2	11	....	....	....	....	....	4	....	....	5	....	1	2	1	....	1	....	....	3	....	....	....	....	43
broken	7	4	6	....	....	....	....	1	5	....	....	2	....	....	1	....	....	....	....	....	2	....	....	....	....	22
lost	3	....	5	....	....	....	....	....	3	....	....	1	....	....	....	....	....	....	....	....	1	1	....	....	....	14
Toes injured	9	2	13	....	....	....	....	....	2	....	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	27
broken	3	2	4	....	....	....	....	....	3	....	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	12
lost	6	1	3	....	....	....	....	....	2	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	15
Internal injuries	20	4	15	1	....	....	....	3	1	....	2	1	....	....	....	....	....	3	....	2	....	....	....	....	....	35
Rupture (hernia)	2	....	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	9	....	....	....	....	....	12
Total	2,695	765	1,982	205	3	221	3	153	167	....	121	79	103	11	149	96	17	51	23	65	159	23	32	13	6	6,719

* See footnote, Table 64.

FATALITIES AT BITUMINOUS COAL MINES.

Inasmuch as bituminous coal mining differs so much from the mining of anthracite, Tables 67 and 68, covering the bituminous coal-mining industry from 1890 to and including 1914, have been compiled. Complete data prior to 1890 would be desirable, but for a study of present-day mine accidents it is believed that these tables go back sufficiently far to show the actual hazards of the bituminous mines.

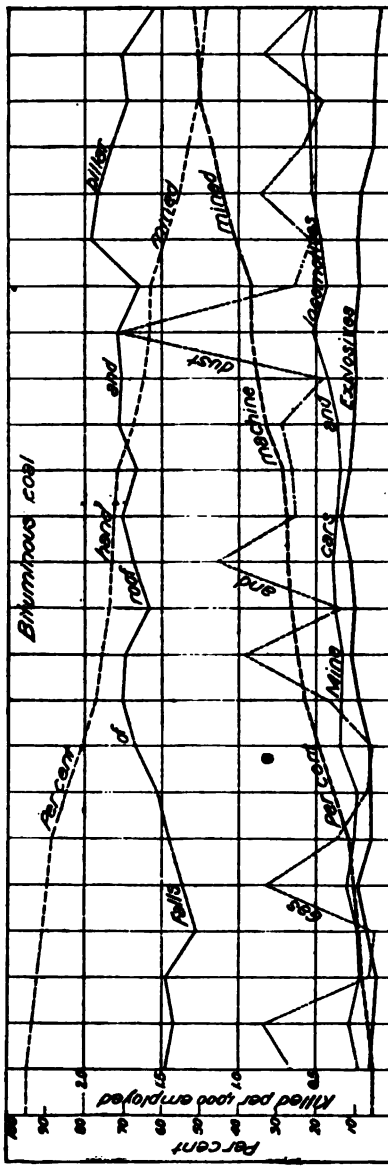


FIGURE 8.—Fatality rates, by principal causes, in bituminous coal mines of the United States, 1891–1914, as compared with the increase in the percentage of machine-mined coal. (Based on Table 68.)

The total production and the number of men employed in all bituminous mines of the United States are given in Table 67. In the second part of the same table are given the production and number of men employed in those States which are under inspection service and for which accident records are available. In 1890, 89.60 per cent was represented by inspection States, whereas for the same year 85.96 per cent of the employees were in the same group.

Table 68 shows the fatalities at bituminous mines by the same groups of causes as in Tables 4, 5, and 6, which include the anthracite mines. It also shows the actual number killed in each group and the percentage of fatalities due to each class, as well as the number killed per 1,000 men employed.

Figure 8 shows the fatality rates by principal causes from 1891 to 1914. In 1890 the number killed by falls of roof and pillar coal per 1,000 men employed was 1.259. This rate gradually increased until

TABLE No. 67.—PRODUCTION, EMPLOYEES, AND FATALITIES, SHOWING PERCENTAGE OF BITUMINOUS COAL-MINING INDUSTRY FOR WHICH COMPLETE RETURNS ARE AVAILABLE, 1890 TO 1914.

Year.	Total for United States.[a]					Total for States having inspection service, or reporting accidents.							
				Average tonnage.		Production.		Number employed.		Number killed.			Production per death.
	Production (short tons).	Number employed.	Days worked.	Per man per year.	Per man per day.	Short tons.	Per cent of total.	Number.	Per cent of total.	Total.	Per 1,000 employed.	Per million tons mined.	
1890	111,302,322	192,204	226	579	2.56	99,723,850	89.60	165,217	85.96	355	2.15	3.56	280,912
1891	117,901,238	205,803	223	573	2.57	106,989,544	90.75	184,333	89.57	528	2.86	4.94	202,632
1892	126,856,567	212,893	219	596	2.72	113,236,126	89.26	188,090	88.35	573	3.05	5.06	197,620
1893	128,385,231	230,365	204	557	2.73	123,648,977	96.31	222,147	96.43	503	2.26	4.07	245,823
1894	118,820,405	244,603	171	486	2.84	110,218,498	92.76	227,039	92.82	513	2.26	4.65	214,851
1895	135,118,193	239,962	194	563	2.90	132,104,933	97.77	233,107	97.14	721	3.09	5.46	183,235
1896	137,640,276	244,171	192	564	2.94	130,776,747	95.01	231,486	94.80	582	2.51	4.45	224,702
1897	147,617,519	247,817	196	596	3.04	142,120,157	96.28	238,701	96.32	567	2.38	3.99	250,653
1898	166,593,623	255,717	211	651	3.09	160,351,393	96.25	246,337	96.33	651	2.64	4.06	246,316
1899	193,323,187	271,027	234	713	3.05	183,575,167	94.96	255,999	94.46	780	3.05	4.25	235,353
1900	212,316,112	304,375	234	697	2.98	202,796,482	95.52	288,242	94.70	1,078	3.74	5.32	188,132
1901	225,528,149	340,235	225	664	2.94	223,977,380	99.18	335,498	98.61	1,061	3.16	4.74	211,109
1902	260,216,844	370,056	230	703	3.06	255,313,471	98.12	362,076	97.84	1,424	3.93	5.58	179,298
1903	282,749,348	415,777	225	680	3.02	277,457,563	98.13	406,098	97.67	1,408	3.47	5.07	197,056
1904	278,659,689	437,832	202	637	3.15	266,008,103	95.46	417,512	95.36	1,400	3.35	5.26	190,006
1905	315,062,785	460,629	211	684	3.24	308,719,393	97.99	449,962	97.68	1,588	3.53	5.14	194,408
1906	342,874,867	478,425	213	717	3.36	334,673,477	97.61	467,928	97.81	1,581	3.38	4.72	211,685
1907	394,759,112	513,258	234	769	3.29	392,288,224	99.37	507,379	98.85	2,534	4.99	6.46	154,810
1908	332,573,944	516,264	193	644	3.34	326,041,103	98.04	504,699	97.76	1,767	3.50	5.42	184,517
1909	379,744,257	[b] 499,751	.....	760	.....	379,736,904	99.99	499,734	99.99	2,075	4.15	5.46	183,006
1910	417,111,142	555,533	217	751	3.46	417,111,142	100.00	555,533	100.00	2,220	4.00	5.32	187,888
1911	405,907,059	[c] 554,408	211	738	3.50	405,907,059	100.00	554,408	100.00	1,957	3.53	4.82	207,413
1912	450,104,962	548,632	223	820	3.68	450,104,962	100.00	548,632	100.00	1,818	3.31	4.04	247,582
1913	478,523,208	571,899	232	837	3.61	478,523,208	100.00	571,899	100.00	2,167	3.79	4.53	220,823
1914	422,708,970	583,506	207	673	3.25	422,708,970	100.00	583,506	100.00	1,859	3.19	4.40	227,382

[a] Mineral Resources, U. S. Geol. Survey.

[b] Bureau of Census.

[c] Bureau of Mines.

TABLE 68.—FATALITIES IN BITUMINOUS COAL MINES OF THE UNITED STATES, BY PRINCIPAL CAUSES, 1890 TO 1914 (FOR INSPECTION STATES ONLY).

Year.	Falls of roof and pillar coal. (1 and 2)			Mine cars and locomotives. (3)			Gas and dust explosions. (4 and 5)			Explosives.[a] (6)			Miscellaneous underground. (7 to 12)			Total shaft fatalities. (13 to 16)			Total surface fatalities. (17 to 22)			Grand total.		Number men employed.[b]
	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.	
1890	208	58.59	1.259	27	7.60	0.163	6	1.69	0.036	30	8.45	0.182	47	13.24	0.285	21	5.92	0.127	16	4.51	0.097	355	2.149	165,217
1891	272	51.52	1.476	39	7.39	.211	124	23.48	.673	31	5.87	.168	25	4.73	.136	17	3.22	.092	20	3.79	.108	528	2.864	184,333
1892	267	46.60	1.419	56	9.77	.298	158	27.58	.840	26	4.54	.138	29	5.06	.154	25	4.36	.133	12	2.09	.064	573	3.046	188,090
1893	329	65.41	1.481	46	9.15	.207	39	7.75	.176	24	4.77	.108	16	3.18	.072	32	6.36	.144	17	3.38	.076	503	2.264	222,147
1894	293	57.12	1.290	52	10.14	.229	29	5.65	.128	42	8.19	.185	51	9.94	.225	27	5.26	.119	19	3.70	.084	513	2.260	227,030
1895	318	44.10	1.364	70	9.71	.300	193	26.77	.828	53	7.35	.227	34	4.72	.146	31	4.30	.133	22	3.05	.095	721	3.092	233,107
1896	337	57.90	1.456	62	10.65	.268	86	14.78	.371	37	6.36	.160	22	3.78	.095	23	3.95	.099	15	2.58	.065	582	2.514	231,486
1897	360	63.49	1.508	55	9.70	.230	47	8.29	.197	40	7.06	.168	22	3.88	.092	22	3.88	.092	21	3.70	.088	567	2.375	238,701
1898	415	63.75	1.685	84	12.90	.341	35	5.37	.142	41	6.30	.167	22	3.38	.089	21	3.23	.085	33	5.07	.134	651	2.643	246,337
1899	445	57.05	1.733	84	10.77	.328	103	13.20	.402	58	7.44	.227	30	3.85	.117	28	3.59	.110	32	4.10	.125	780	3.047	255,999
1900	498	46.19	1.728	94	8.72	.326	282	26.16	.978	79	7.33	.274	48	4.45	.167	42	3.90	.146	35	3.25	.121	1,078	3.740	288,242
1901	535	50.42	1.595	127	11.97	.378	123	11.59	.367	83	7.82	.247	117	11.03	.349	44	4.15	.131	32	3.02	.095	1,061	3.168	335,498
1902	611	42.91	1.687	144	10.11	.398	413	29.00	1.141	99	6.95	.273	79	5.55	.218	44	3.09	.122	34	2.39	.094	1,424	3.933	362,076
1903	711	50.50	1.751	151	10.72	.372	262	18.61	.645	138	9.80	.339	50	3.55	.123	38	2.70	.094	58	4.12	.143	1,408	3.467	406,098
1904	697	49.79	1.669	144	10.29	.345	271	19.36	.649	121	8.64	.290	56	4.00	.134	59	4.21	.141	52	3.71	.125	1,400	3.353	417,512
1905	801	50.44	1.780	165	10.39	.367	316	19.90	.702	119	7.49	.264	80	5.04	.178	36	2.27	.080	71	4.47	.158	1,588	3.539	449,962
1906	826	52.25	1.765	189	11.95	.404	219	13.85	.468	115	7.27	.246	82	5.19	.175	73	4.62	.156	77	4.87	.165	1,581	3.378	467,928
1907	911	35.95	1.796	256	10.10	.504	911	35.95	1.796	134	5.29	.264	152	6.00	.299	59	2.33	.116	111	4.38	.219	2,534	4.994	507,379
1908	829	46.91	1.645	222	12.56	.440	320	18.11	.634	109	6.17	.216	157	8.89	.311	53	3.00	.105	77	4.36	.152	1,767	3.501	504,699
1909	975	46.99	1.951	236	11.37	.472	264	12.72	.528	122	5.88	.244	368	17.74	.737	37	1.78	.074	73	3.52	.146	2,075	4.152	499,734
1910	1,061	47.79	1.910	287	12.93	.516	477	21.49	.859	113	5.09	.203	130	5.86	.234	60	2.70	.108	92	4.14	.166	2,220	3.996	555,533
1911	1,007	51.46	1.816	290	14.82	.523	331	16.91	.597	72	3.68	.130	140	7.15	.253	31	1.58	.056	86	4.40	.155	1,957	3.530	554,408
1912	943	51.87	1.719	292	16.06	.532	255	14.02	.465	70	3.85	.128	123	6.77	.224	39	2.15	.071	96	5.28	.175	1,818	3.314	548,632
1913	1,007	46.47	1.761	339	15.64	.593	464	21.41	.811	63	2.91	.110	166	7.66	.290	32	1.48	.056	96	4.43	.168	2,167	3.789	571,899
1914	903	48.58	1.548	304	16.35	.521	305	16.41	.523	56	3.01	.096	146	7.85	.250	41	2.21	.070	104	5.59	.178	1,859	3.186	583,506

[a] See also figures 5 and 8.

[b] See also Table 67.

in 1909 it was 1.951. Since 1909 the rate has been decreasing until in 1914 it was 1.548 per 1,000 men employed. With reference to mine cars and locomotives the fatality rate per 1,000 men employed in 1890 was 0.163. The rate increased quite uniformly to 0.593 per 1,000 employed in 1913. The rate for 1914 was slightly lower. The fatality rates due to gas and dust explosions have been very erratic, reaching the highest point in 1907, when the rate was 1.796 per 1,000 employed. Since the year 1907 this rate has decreased, although irregularly, to 0.523 per 1,000 employed in 1914.

The fatality rate due to explosives gradually increased from 1890, during which year the rate was 0.182 per 1,000 employed, to 1903, when it reached its highest point, 0.339 per 1,000. Since the introduction of permissible explosives and more strict rules concerning the handling and use of explosives, together with more efficient mine-inspection service, the fatality rate has gradually decreased until in 1914 the number killed per 1,000 employed was 0.096. This reduction is illustrated in figures 5 and 8.

The number of accidents at shafts has decreased slightly, whereas the number of those on the surface shows a gradual increase.

The percentage of coal mined by machines since 1891, when the first records are available, is shown in figure 10. In 1891 only 5.26 per cent of the bituminous coal was mined by machines. The quantity has steadily increased year by year until in 1914, 51.7 per cent of the coal was reported as machine mined. The upper curve in figure 10 includes all hand-mined coal as well as that shot off the solid as distinguished from the machine product. Details of accidents as related to machine mining follow.

MACHINE MINING.

A study of coal-mine accidents would not be complete without some reference to machine mining. It would be very desirable, indeed, if it were possible to tabulate data for a period of years, showing the actual number of men employed in machine-worked mines, together with the corresponding casualties occurring therein. Data of this character are not available, however, and hence it is impossible to make such a study. The United States Geological Survey, however, has for a number of years, 1896–1913, collected and published data showing the percentage of coal mined by machines in each State, and this information is used as a basis for the study of mine accidents as tabulated herein.

In comparing figures of production, number of men employed, fatalities, etc., for the 18-year period, those States have been included in which complete accident-fatality records and the number of employees are available. Inasmuch as details are lacking to show the number of mines where mining machines are used, the only other alternative whereby comparative results may be obtained is to group the States according to the percentage of coal mined by

TABLE 69.—NUMBER OF MACHINES USED IN THE VARIOUS COAL-MINING STATES.*

State.	Number of machines used in the year—																			
	1891	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914
Alabama	.....	.....	45	37	53	54	82	66	98	141	213	238	197	197	283	317	272	353	377	362
Arkansas	.....	14	15	21	16	20	20	7	.....	.....	.....	.....	.....	.....	.....	12	14	9	27	28
California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	2	2
Colorado	20	34	37	43	63	90	62	98	157	125	121	141	175	211	253	256	242	304	300	306
Georgia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	.....	.....	.....	.....	.....	.....
Idaho	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Illinois	241	307	320	393	440	430	464	508	553	643	883	1,048	1,080	1,217	1,260	1,361	1,402	1,654	1,845	1,812
Indiana	47	186	174	233	247	254	256	269	329	403	506	471	513	507	631	645	667	687	752	751
Iowa	9	45	49	56	41	40	53	31	10	39	32	34	33	28	5	17	20	24	28	46
Kansas	.....	.....	1	2	3	3	4	6	5	5	10	6	6	17	16	13	15	11	9	9
Kentucky	.....	.....	162	158	189	239	237	318	308	453	527	600	708	759	877	899	977	1,168	1,263	1,383
Maryland	.....	.....	.....	8	16	15	25	36	38	42	45	43	39	39	38	37	53	13	10	
Michigan	.....	.....	7	25	33	31	58	46	85	106	110	103	120	101	100	113	126	130	107	
Missouri	.....	4	3	4	9	15	24	20	33	31	30	48	62	57	96	98	92	86	104	88
Montana	.....	62	61	62	75	81	70	65	63	57	58	76	86	57	81	99	87	69	97	99
New Mexico	.....	.....	.....	29	14	21	6	17	12	12	.....	.....	3	7	4	3	10	25	44	45
North Dakota	.....	1	2	7	5	7	7	10	9	9	9	11	12	11	16	13	11	11	13	14
Ohio	114	209	224	245	278	341	376	559	724	865	1,041	1,255	1,328	1,343	1,433	1,452	1,536	1,547	1,681	1,669
Oklahoma	.....	56	54	75	74	58	47	23	36	18	29	29	11	17	34	13	26	60	103	116
Pennsylvania (bituminous)	72	454	690	1,085	1,343	1,786	2,058	2,620	3,310	3,645	4,254	4,515	4,940	5,103	5,616	5,505	5,719	6,176	6,301	6,326
Tennessee	.....	.....	8	19	22	18	21	38	51	85	89	128	137	122	197	178	179	227	252	194
Texas	.....	.....	5	5	.....	.....	8	8	8	9	8	12	13	6	11	14	15	21	24	13
Utah	.....	1	.....	.....	.....	.....	13	13	13	9	.....	2	5	.....	.....	7	7	13	50	68
Virginia	.....	.....	8	8	8	9	6	11	10	18	35	37	77	85	107	142	156	185	187	182
Washington	.....	3	.....	.....	2	2	4	.....	.....	.....	.....	1	.....	4	18	10	23	56	63	72
West Virginia	8	25	47	86	154	327	403	579	788	901	1,105	1,322	1,533	1,574	1,844	1,966	2,044	2,253	2,539	2,607
Wyoming	34	39	45	48	56	69	74	69	59	72	81	83	79	88	127	98	155	179	195	198
Total	545	1,440	1,950	2,632	3,125	3,907	4,341	5,418	6,658	7,663	9,184	10,212	11,144	11,569	13,049	13,254	13,819	15,298	16,379	16,597
Coal mined per machine (tons)	11,398	11,373	11,579	12,362	14,068	13,510	13,325	12,848	11,712	10,258	11,258	11,638	12,381	10,648	10,920	13,127	12,854	13,763	14,801	13,231

* Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

machines. Four groups have therefore been used as follows: Group I includes those States in which less than 20 per cent of the coal produced was mined by machines, leaving the other 80 per cent of the coal as mined by hand or shot off the solid. Group II includes those States in which 20 to 39 per cent of the coal produced was mined by machines. Group III includes those States in which 40 to 59 per cent of the coal produced was mined by machines. Group IV includes those States in which 60 per cent or more was produced by mining machines.

TABLE 70.—NUMBER AND TYPE OF COAL-CUTTING MACHINES IN OPERATION IN THE UNITED STATES, 1899 TO 1914, INCLUSIVE.[a]

Year.	Number of machines in use.					
	Pick.	Chain breast.	Long wall.	Short wall.	Radial axe or post.	Total.
1899	1,997	1,106	22	.....	.....	3,125
1900	2,350	1,509	48	.....	.....	3,907
1901	2,580	1,716	45	.....	.....	4,341
1902	3,185	2,182	51	.....	.....	5,418
1903	3,887	2,717	54	.....	.....	6,658
1904	4,483	3,102	78	.....	.....	7,663
1905	5,525	3,557	102	.....	.....	9,184
1906	5,911	4,144	157	.....	.....	10,212
1907	6,227	4,652	265	.....	.....	11,144
1908	6,380	4,992	197	.....	.....	11,569
1909	7,107	5,090	352	.....	.....	12,549
1910	6,716	5,973	518	47	.....	13,254
1911	6,535	5,943	481	777	83	13,819
1912	6,833	6,425	545	1,371	124	15,298
1913	6,327	6,486	791	2,208	117	16,379
1914	5,878	6,359	618	3,024	128	16,007

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

GROUPING OF STATES, ACCORDING TO PERCENTAGE OF COAL MINED BY MACHINES, FOR THE PERIOD 1896–1913, AND NUMBER OF YEARS EACH STATE IS REPRESENTED IN EACH GROUP.

[Group I, less than 20 per cent mined by machine; Group II, 20 to 39 per cent; Group III, 40 to 59 per cent; Group IV, 60 per cent or more.]

Coal-mining States.	Group.			
	I	II	III	IV
	Years.	*Years.*	*Years.*	*Years.*
Alabama	16	2	.....	.....
Arkansas	14	.....	.....	.....
California	5	.....	.....	.....
Colorado	16	2	.....	.....
Georgia	4	.....	.....	.....
Illinois	6	9	3	.....
Indiana	.....	12	6	.....
Iowa	18	.....	.....	.....
Kansas	18	.....	.....	.....
Kentucky	1	4	8	5
Maryland	18	.....	.....	.....
Michigan	3	8	3	1
Missouri	15	3	.....	.....
Montana	.....	7	8	1
New Mexico	17	1	.....	.....
North Carolina	2	.....	.....	.....
North Dakota	.....	4	2	.....
Ohio	.....	3	6	9
Oklahoma	18	.....	.....	.....
Oregon	4	.....	.....	.....
Pennsylvania (bituminous)	2	7	9	.....
Tennessee	17	1	.....	.....
Texas	4	.....	.....	.....
Utah	18	.....	.....	.....
Virginia	3	3	2	.....
Washington	18	.....	.....	.....
West Virginia	5	8	5	.....
Wyoming	5	5	1	.....

TABLE 71.—SUMMARY OF PRODUCTION, MEN EMPLOYED, AND NUMBER KILLED IN AND ABOUT THE BITUMINOUS COAL MINES, BY GROUPS, BASED ON PERCENTAGE OF COAL MINED BY MACHINES, 1896 TO 1913, INCLUSIVE.

[See fig. 10.]

Group.	Percentage mined by machine.	Grand total for group.			Total for States having accident statistics.												
		Production (short tons).	Men employed.	Tons mined per man.	Production (short tons).	Percentage mined by machine.	Men employed.	Days active.	Number killed.			Number killed per 1,000 employed.			Number killed per million tons mined.	Tons mined per man.	
									Total.	In exceptional accidents.	In common accidents.	Total.	In exceptional accidents.	In common accidents.		Per year.	Per day.
I	0 to 19	1,382,677,130	2,340,459	591	1,323,700,958	9.40	2,230,797	218	9,116	2,476	6,640	4.09	1.11	2.98	6.89	593	2.72
II	20 to 39	1,584,880,534	2,180,510	727	1,559,863,477	31.45	2,149,868	212	7,675	1,633	6,042	3.57	.76	2.81	4.92	726	3.42
III	40 to 59	2,100,257,254	2,542,583	826	2,098,210,230	46.96	2,539,165	227	8,394	967	7,427	3.31	.38	2.92	4.00	826	3.64
IV	60+	353,791,180	522,444	677	353,707,285	77.48	522,293	192	1,473	107	1,366	2.82	.20	2.62	4.16	677	3.53

TABLE 72.—PERCENTAGE OF FATALITIES AND RATE PER 1,000 MEN EMPLOYED, BY PRINCIPAL CAUSES, IN AND ABOUT THE BITUMINOUS COAL MINES, BY GROUPS, BASED ON PERCENTAGE OF COAL MINED BY MACHINES, 1896 TO 1913, INCLUSIVE.

Group.	Falls of roof and pillar coal. (1 and 2)			Mine cars and locomotives. (3)			Gas and dust explosions. (4 and 5)			Explosives. (6)			Miscellaneous underground. (7 to 12)			Total shaft fatalities. (13 to 16)			Total surface fatalities. (17 to 22)			Grand total.	
	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.
I	3,798	41.66	1.70	783	8.59	0.35	2,680	29.40	1.20	739	8.11	0.33	616	6.76	0.28	231	2.53	0.11	269	2.95	0.12	9,116	4.09
II	3,723	48.51	1.73	874	11.39	.41	1,423	18.54	.66	486	6.33	.23	578	7.53	.27	271	3.53	.12	320	4.17	.15	7,675	3.57
III	4,551	54.22	1.79	1,337	16.52	.55	974	11.60	.39	308	3.67	.12	536	6.39	.21	207	2.47	.08	431	5.13	.17	8,394	3.31
IV	997	60.90	1.72	177	12.02	.34	102	6.92	.19	80	5.43	.15	114	7.74	.22	32	2.17	.06	71	4.82	.14	1,473	2.82

The fatalities during this period have been divided into two classes, namely, common and exceptional. Common accidents are those of daily occurrence in which less than 5 men are killed at one time. Exceptional accidents are defined as those including mine disasters in which 5 or more men are killed at one time.

PRODUCTION.

Table 73 shows the production of coal for Group I from 1896 to 1913. The production of this group, 113,995,776 tons in 1896, has gradually declined until in 1913 it was only 39,509,308 tons. Group II (Table 76) produced in 1896, 16,780,981 tons and reached its highest point in 1902. In 1913 the production of this group was 41,373,914 tons. A number of States, in Group II, passed from this group into Group III (Table 79) in 1904, so that Group III, while not producing any coal in 1896, produced 340,591,068 tons in 1913. Group IV (Table 82), in which more than 60 per cent was mined by machines, does not make its appearance until 1900. It then dropped out for four years and appeared again in 1905 with 25,552,950 tons. In 1913 this group produced 57,048,913 tons.

NUMBER OF MEN EMPLOYED.

Tables 73, 76, 79, and 82 show the number of men employed in each group for the period covered (fig. 9). The number employed in Group I, 197,180 men in 1896, has gradually declined until in 1913 there were 67,714 employed in this class of mines. Group II began in 1896 with only 34,306 men and gradually increased to 207,976 men in 1904. At the close of 1904 a large percentage of this group passed into Group III, so that although Group III does not show any employees in 1896 there were 366,880 employees in 1913. The number of men in Group IV varies from none in 1904 to 75,452 in 1913.

EFFECT OF MACHINE MINING ON FATALITY RATES.

Table 69 shows by States and years the number of mining machines in use from 1891 to 1914. During this period the number of machines has increased from 545 to about 17,000, and the production per year per machine has increased from 11,398 tons in 1891 to 14,802 tons in 1913. Table 70 shows the number of each of five different types of machines in use since 1899.

As there has been an enormous increase in the use of mining machines, Tables 69 to 85 have been compiled for the purpose of analyzing accidents as related to this method of mining. When mining machines were first introduced, there were many who felt that they added another serious hazard to the coal-mining industry.

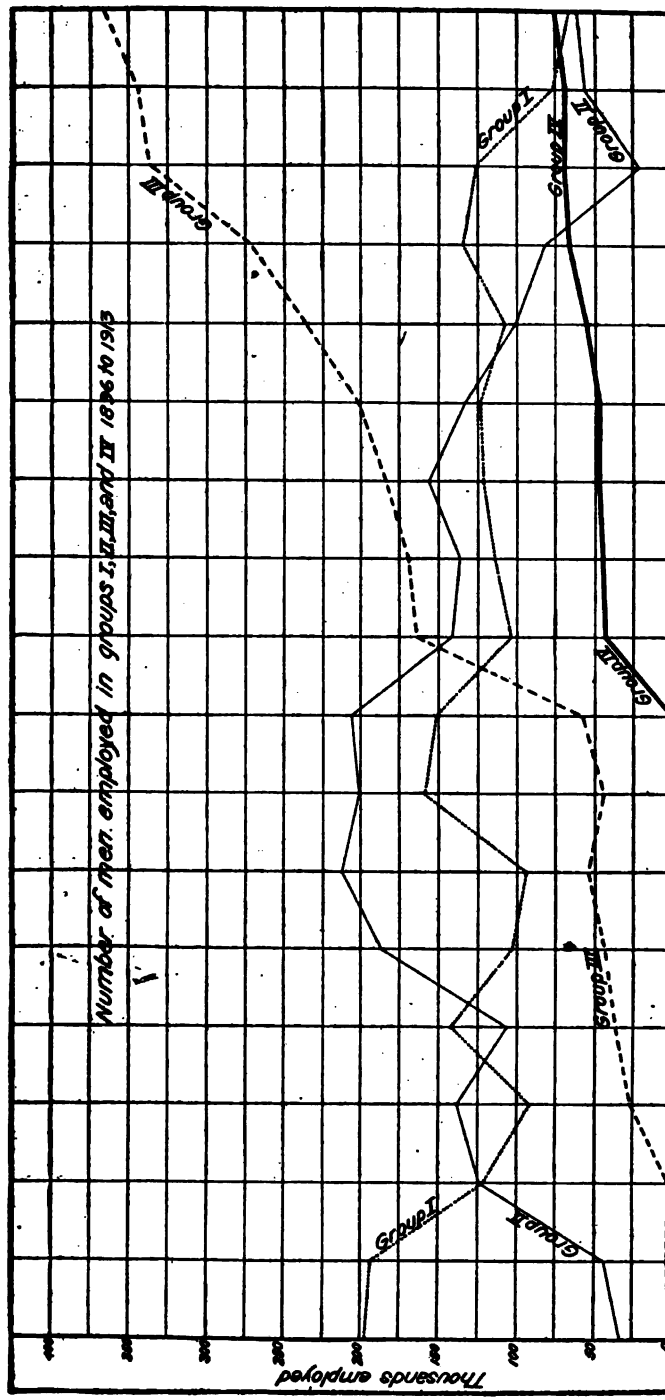


FIGURE 9.—Number of men employed in bituminous coal mines of the United States, by groups, based on percentage of coal mined by machines, 1896–1913. (Based on Tables 73, 76, 79, and 82.)

Although their use may have increased the number of accidents due to machinery and electricity, yet the results shown in Tables 69 to 85 and figures 10 to 15 do not seem to bear out the first impression. The increase of accidents due to machinery and electricity seems to be more than offset by the decrease in fatalities due to explosives, as shown in Table 5.

As indicated, the fatality rate, in those groups where the percentage of machine mining is largest, is lower than in those groups where the amount of coal undercut by hand or shot from the solid is the largest.

As indicated in Table 71 and figure 10, the first three groups are practically of the same rank, each employing slightly over 2,000,000 men during the 18-year period. Group IV is much smaller, employing only 522,293 men. The total production for the first three groups is nearly the same, so that comparisons for those groups may be made on an equal basis. The total number of men killed in exceptional accidents, in all of the groups, was 5,183, and in common accidents, 21,475. In Group I the number of fatalities due to exceptional accidents was 2,476, representing a rate of 1.11 per 1,000 employed. The exceptional-accident rates per 1,000 men employed are 0.76 for Group II, 0.38 for Group III, and 0.20 for Group IV. The rates for common accidents are 2.98 for Group I, 2.81 for Group II, 2.92 for Group III, and 2.62 for Group IV. There is a gradual decline in the total-fatality rate, ranging from 4.09 per 1,000 employed, in Group I, to 2.82 in Group IV. The number of fatalities per million tons mined in Group I is 6.89 for the entire period, and in Group III, which has the lowest rate, is 4.00, for Group IV it is 4.16.

In Table 72 (figure 11), the four groups are compared by principal causes of accidents, showing the percentage of fatalities and the number killed per 1,000 men for each group.

CAUSES OF ACCIDENTS.

The fatalities due to falls of roof (figure 11) are practically the same for each of the four groups, ranging from 1.70 in Group I per 1,000 men employed to 1.79 in Group III. The percentage of fatalities due to falls of roof is lowest in Group I, ranging from 41.66 in Group I to 60.90 in Group IV. The comparison on a percentage basis is not however as true as that based on the actual number of men employed. A sudden increase or decrease in one particular class of accidents affects the total, and percentages derived from this base will be more or less altered. When comparisons are made on the basis of actual number of employees, a large disaster due to one cause will not alter the comparisons for the other causes as the rates are derived from a base that remains unchanged.

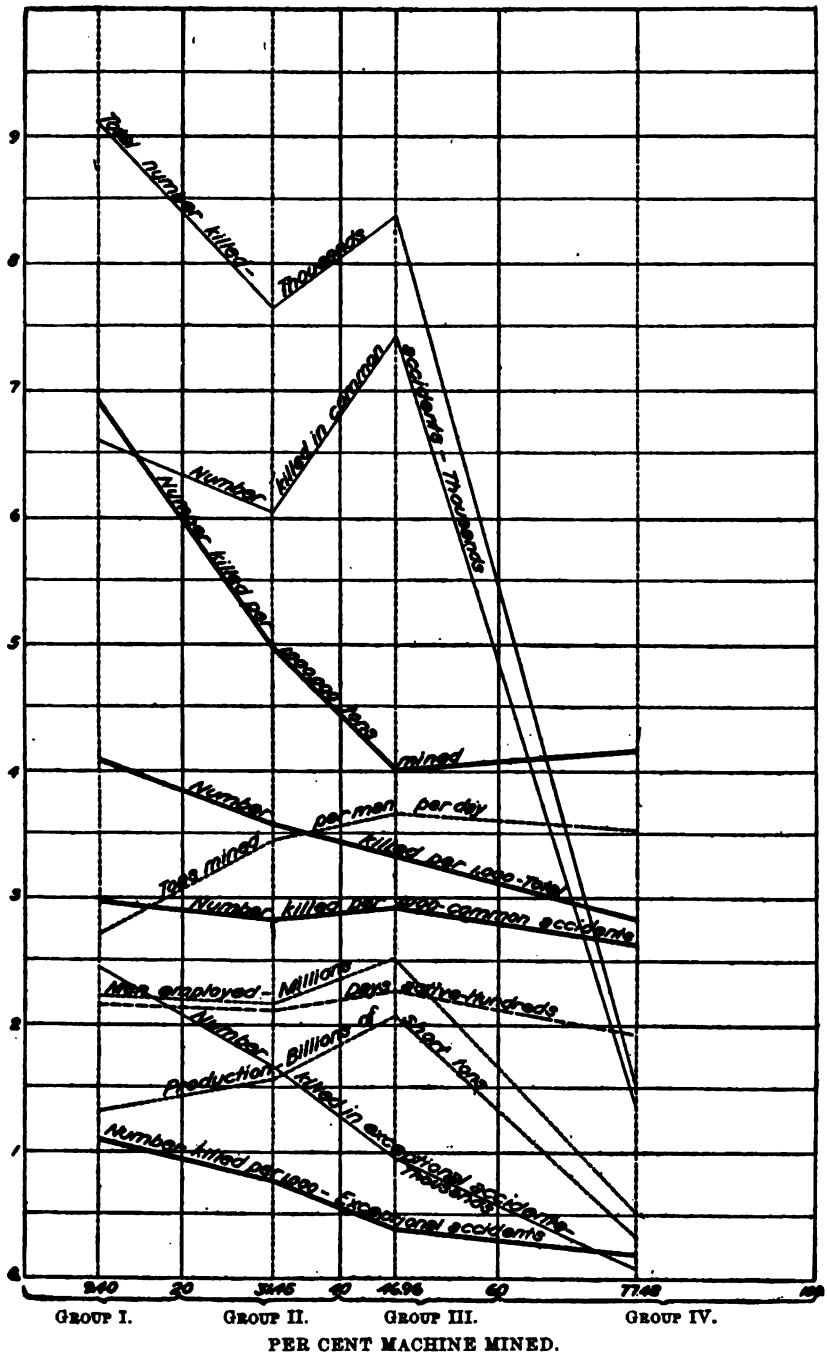


FIGURE 10.—Total number killed, fatality rates, men employed, tons produced, and days active at the bituminous coal mines of the United States, by groups based on the percentage of coal mined by machines, 1906–1913. (Based on Table 71.)

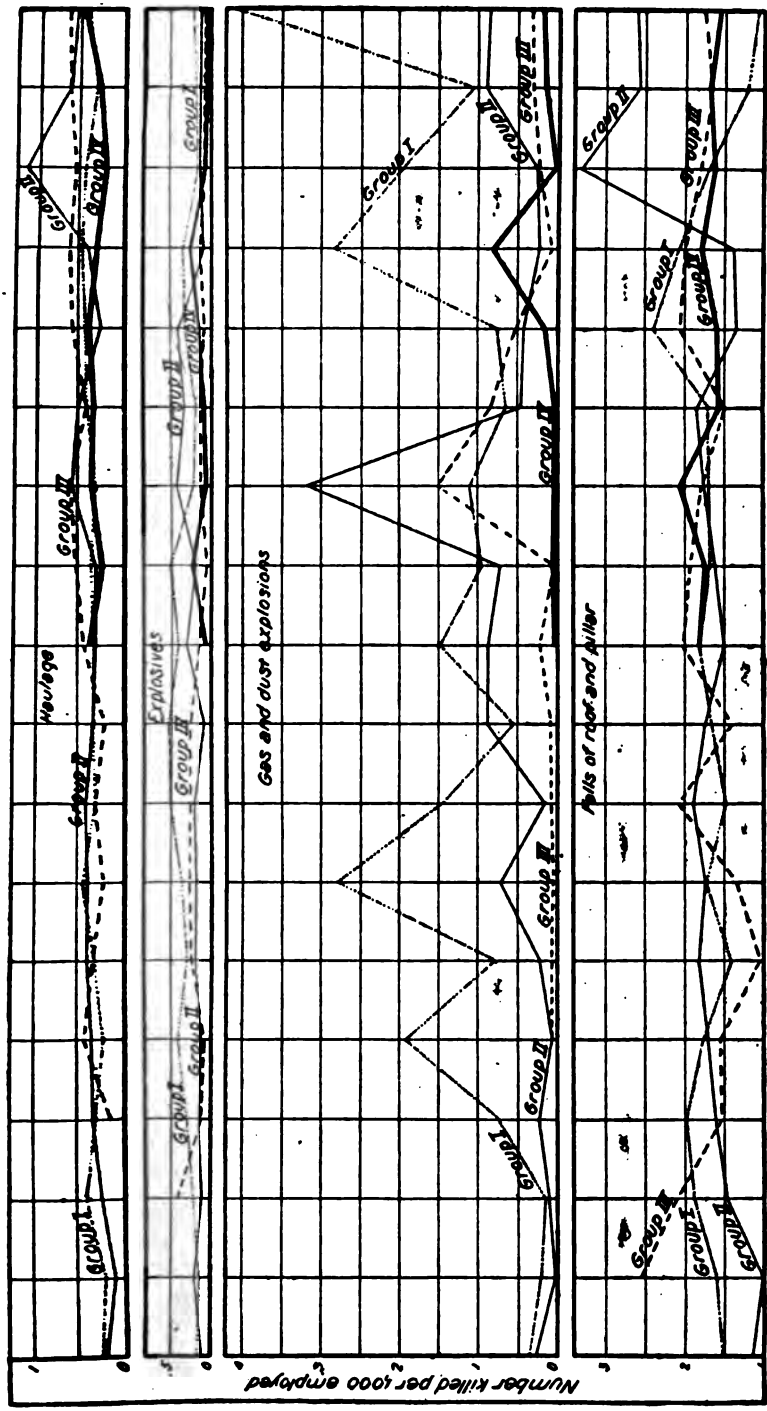


FIGURE 11.—Number of men killed per 1,000 employed in bituminous coal mines of the United States, by principal causes, by groups based on percentage of coal mined by machines, 1896–1913. (Based on Tables 74, 77, 80, and 83.)

There is but little difference in the fatality rate by reason of accidents due to mine cars and locomotives (fig. 11). In Groups I and IV the rates are practically the same, being 0.35 and 0.34 respectively, but in Groups II and III the rates are slightly higher.

GAS AND DUST EXPLOSIONS.

The most striking difference in the number of fatalities in the various groups is in accidents due to gas and dust explosions. It will be noted that 29.40 per cent of all of the fatalities in Group I were due to gas and dust explosions, and that the percentage due to this cause declines as the percentage of machine-mined coals, only 6.92 per cent of the total fatalities in Group IV being due to this cause. As stated above, the percentage comparison is not as fair as that based on the number of men employed. The fatality rate in Group I due to gas and dust explosions was 1.20 per 1,000 men employed during the 18-year period, in Group II the rate was 0.66, in Group III, 0.39, and in Group IV, 0.19 per 1,000 employed. These differences are shown in figure 11.

EXPLOSIVES.

As would be expected, the fatality rate due to explosives (fig. 11) is higher in Group I than in the other groups. In Group I the maximum amount of explosives is used and much of the coal mined is shot off the solid; its fatality rate is 0.33 per 1,000 men employed. In Groups II, III, and IV, where less explosives are used, the fatality rates are 0.23, 0.12, and 0.15 per 1,000 employed, respectively. In the latter two groups there is a minimum amount of explosives used in the coal mines.

With reference to miscellaneous underground, shaft, and surface accidents there is no variation of importance.

MINING CONDITIONS.

These figures are not absolute proof that lower fatality rates in Group IV as compared with Group I are due to the larger use of machines in the mines of Group IV. Many small mines are included in Group I in which hand mining prevails. The small mines do not always have the most improved equipment, and many times less attention is given to safety measures. The mines in Group I use a maximum amount of explosives, are operated under all classes of roof conditions, and include all types of coal beds ranging from thick to thin with various degrees of inclination, from horizontal to vertical.

The hand-mining mines are in most cases operated more hours a day and, as shown in Table 71, more days a year as compared with Group IV. The number of days active is 218 for Group I, 212 for Group II, 227 for Group III, and 192 for Group IV. With the excep-

tion of Kentucky, the employees in Group IV are all on an 8-hour basis. The other groups contain many 9 and 10 hour men.

As regards the mines in which the major part of the coal is mined by machine, they include but few small mines and hence have more systematic management. When a mine has reached the stage where the management is financially able to install machines, it is usually conducted on a more business-like basis than are the small and poorly financed properties, has better haulage systems, and more efficient ventilation. In machine mining a minimum amount of explosives is used and in a mine where machines are introduced it is essential that good roof conditions prevail and that the coal bed is of reasonably uniform thickness. Also machines are operated in the flatter lying beds and are seldom used in the steeply inclined measures. The majority of the States in which the largest percentage of coal is mined by machines are operated on an 8-hour basis and less days per year, hence the time of exposure to the dangers of mining is less.

FATALITY RATES ON BASIS OF COAL MINED BY MACHINE.

The total fatality rate at the four groups of mines, based on the percentage of machine-mined coal, from 1896 to 1913, is shown in figure 12. The upper part of the figure represents, as indicated, the total fatality rate at bituminous coal mines during this period. The second or middle part of the figure shows the fatality rate due to "common" accidents, that is, those in which less than 5 men are killed at one time. These rates are reasonably close together, Group IV showing the lowest and Group I, as a whole, the highest rate. The lower part of the figure shows the fatality rate due to "exceptional" accidents. Here again Group I is high, and is followed closely by Group II; Group IV is exceedingly low.

The amount of coal mined per day per man in the various groups of mines is given in figure 13. The curves show that in Group I, in which less than 20 per cent of the coal was mined by machine, the average number of tons mined per day is 2.72 (Table 73), while in Group III it ranges from 2.80 to about 3.90 tons per day. Group II is more erratic, and since 1910 many of the mines originally in this group have passed into Group III, so that since that year there has been a decrease in the amount of coal produced per man per day. Group IV remains practically stationary, with an average of 3.53 tons per day.

Figure 13 also shows the fatalities per million tons mined according to the four groups outlined above. In Group I the fatality rate is exceedingly high when based on the number of tons mined per fatality. This rate varies from 4.06 to 10.68, the average being 6.89 (Table 73). As would be expected, the number of fatalities per million tons produced in Groups III and IV are considerably lower than in the other two groups, the average being, respectively, 4.00 and 4.16.

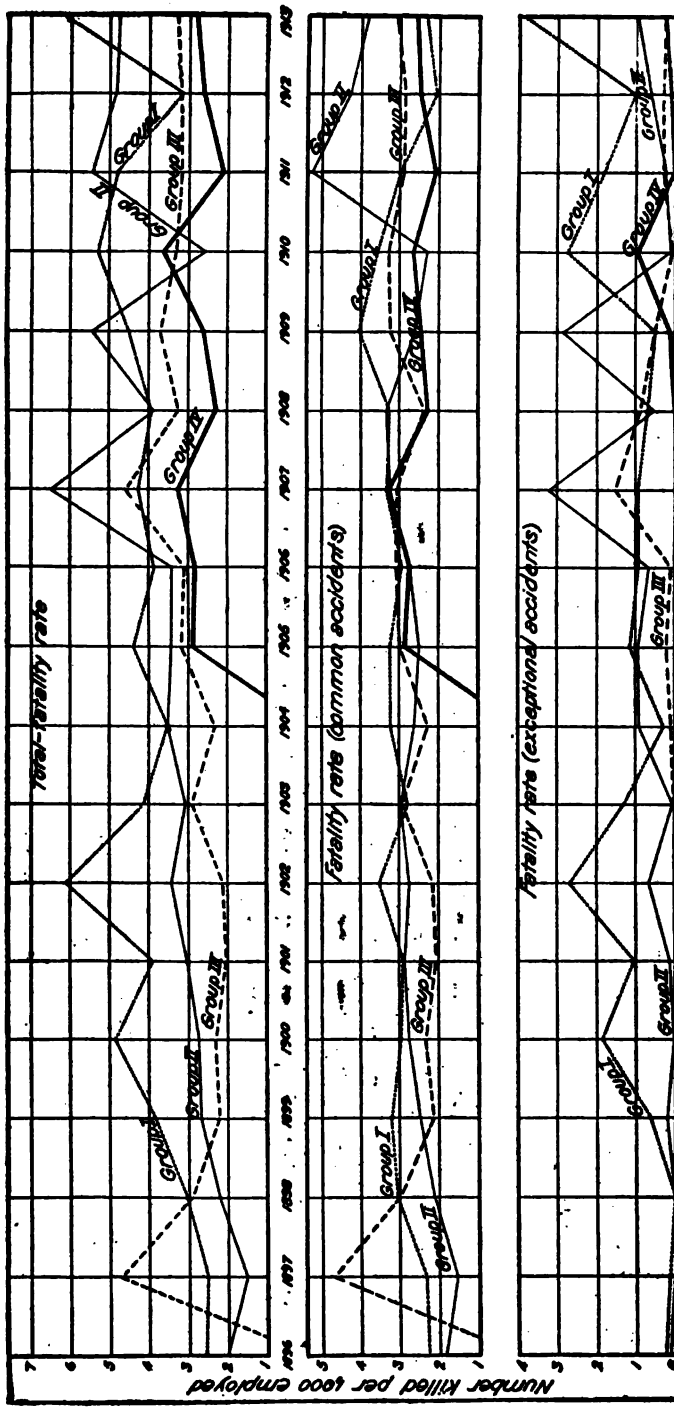


FIGURE 12.—The total number killed per 1,000 employed in bituminous coal mines of the United States; also number killed per 1,000 employed in common and in exceptional accidents, by groups based on percentage of coal mined by machine, 1896–1913. (Based on Tables 73, 76, 79, and 82.)

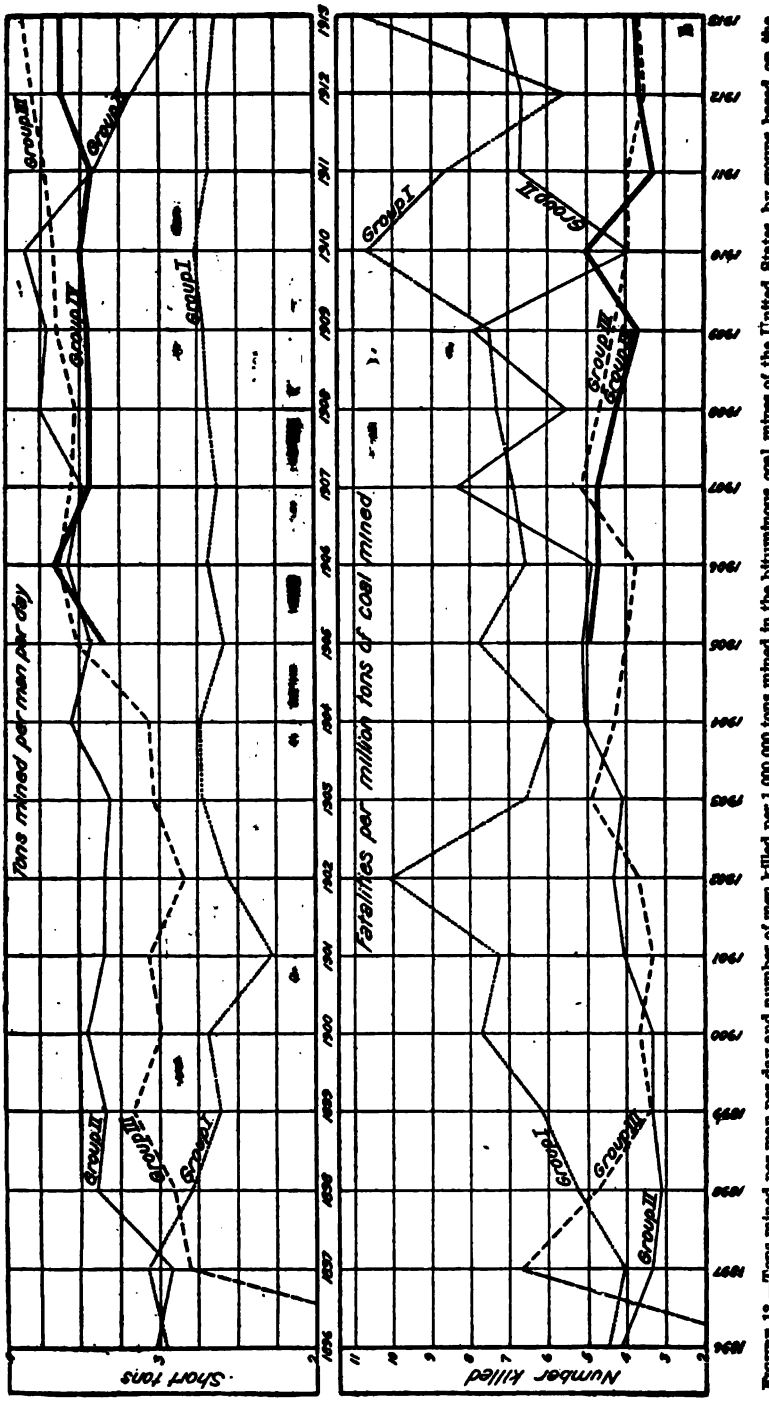


FIGURE 13.—Tons mined per man per day and number of men killed per 1,000,000 tons mined in the bituminous coal mines of the United States, by groups based on the percentage of coal mined by machine, 1896–1913. (Based on Tables 73, 76, 79, and 82.)

TABLE 73.—PRODUCTION, MEN EMPLOYED, AND NUMBER KILLED IN AND ABOUT THE BITUMINOUS COAL MINES IN THE UNITED STATES IN WHICH LESS THAN 20 PER CENT OF THE COAL WAS MINED BY MACHINES, 1896 TO 1913, INCLUSIVE, GROUP I.

[See figs. 9, 12, and 13.]

Year.	Grand totals, Group I.			Totals for States in Group I having accident statistics.											
	Production (short tons).	Men employed.	Tons mined per man.	Production (short tons).	Percentage mined by machine.	Men employed.	Days active.	Number killed.			Number killed per 1,000 employed.			Number killed per million tons mined.	Tons mined per man.	
								Total.	In exceptional accidents.	In common accidents.	Total.	In exceptional accidents.	In common accidents.		Per year.	Per day.
1896	119,315,850	207,710	574	113,995,766	9.70	197,180	196	512	62	450	2.60	0.32	2.28	4.49	578	2.95
1897	121,815,995	196,550	620	120,522,067	12.31	193,065	203	489	36	453	2.53	.19	2.34	4.06	624	3.07
1898	76,539,274	130,025	589	70,380,939	8.94	120,796	208	370	.....	370	3.06	.....	3.06	5.26	583	2.80
1899	62,868,180	101,950	617	56,821,211	5.90	91,470	238	352	59	293	3.85	.65	3.20	6.19	621	2.61
1900	99,031,453	158,249	626	89,641,706	11.82	142,442	224	690	266	424	4.85	1.87	2.98	7.70	629	2 69
1901	57,227,549	107,692	531	55,543,381	5.09	103,235	236	404	105	299	3.91	1.02	2.89	7.27	538	2.28
1902	61,646,924	101,682	606	56,970,662	5.14	94,104	236	579	254	325	6.15	2.70	3.45	10.16	605	2.56
1903	105,356,647	169,010	623	100,343,507	13.23	159,817	231	658	210	448	4.12	1.32	2.80	6.56	628	2.72
1904	97,343,516	165,773	587	90,142,414	11.60	151,667	217	532	46	486	3.51	.30	3.21	5.90	594	2.74
1905	65,505,874	114,681	571	59,480,024	7.40	104,630	219	460	121	339	4.40	1.16	3.24	7.73	568	2.59
1906	69,717,418	118,911	586	67,955,711	7.75	114,836	220	448	110	338	3.90	.96	2.94	6.59	592	2.69
1907	77,672,485	126,603	614	75,549,357	8.29	121,286	237	518	114	404	4.27	.94	3.33	6.86	623	2.63
1908	68,669,809	128,392	535	66,396,010	9.47	123,035	201	485	88	397	3.94	.71	3.23	7.30	540	2.69
1909	65,889,437	108,113	609	65,382,084	8.08	108,096	224	490	56	434	4.53	.52	4.01	7.44	609	2.72
1910	80,432,574	134,777	597	80,432,574	10.63	134,777	215	854	370	484	6.34	2.75	3.59	10.62	597	2.78
1911	70,259,469	126,173	557	70,259,469	10.58	126,173	207	610	234	376	4.83	1.85	2.98	8.68	557	2.69
1912	43,875,368	76,454	574	43,875,368	5.93	76,454	213	243	82	161	3.18	1.07	2.11	5.54	574	2.69
1913	39,509,308	67,714	583	39,509,308	6.72	67,714	220	422	263	159	6.23	3.88	2.35	10.68	583	2.65
Total	1,282,677,130	2,340,459	581	1,223,709,966	9.40	2,230,797	218	9,116	2,476	6,640	4.09	1.11	2.96	6.89	563	2.72

TABLE 74.—PERCENTAGE OF FATALITIES AND RATE PER 1,000 MEN EMPLOYED, BY PRINCIPAL CAUSES AT BITUMINOUS COAL MINES IN THE UNITED STATES IN WHICH LESS THAN 20 PER CENT OF THE COAL WAS MINED BY MACHINES, GROUP I.

(See fig. 11.)

Year.	Falls of roof and pillar coal. (1 and 2)			Mine cars and locomotives. (3)			Gas and dust explosions. (4 and 5)			Explosives. (6)			Miscellaneous underground. (7 to 12)			Total shaft fatalities. (13 to 16)			Total surface fatalities. (17 to 22)			Grand total.	
	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.
1896	297	58.01	1.51	54	10.55	0.27	76	14.84	0.38	33	6.45	0.17	21	4.10	0.11	17	3.32	0.09	14	2.73	0.07	512	2.60
1897	310	63.39	1.60	44	9.00	.23	45	9.20	.23	31	6.34	.16	21	4.29	.11	19	3.89	.10	19	3.89	.10	489	2.52
1898	228	61.62	1.89	49	13.24	.41	23	6.22	.19	26	7.03	.21	9	2.43	.07	14	3.78	.12	21	5.68	.17	370	3.06
1899	182	51.70	1.99	31	8.81	.34	69	19.60	.75	29	8.24	.32	14	3.98	.15	11	3.12	.12	16	4.55	.18	352	3.85
1900	253	36.67	1.78	36	5.22	.25	273	39.56	1.92	59	8.55	.41	34	4.93	.24	17	2.46	.12	18	2.61	.13	690	4.85
1901	145	35.89	1.40	34	8.42	.33	81	20.05	.79	32	7.92	.31	37	21.53	.84	19	4.70	.18	6	1.49	.06	404	3.91
1902	165	28.50	1.75	43	7.42	.46	261	45.08	2.77	37	6.39	.39	53	8.98	.55	10	1.73	.11	11	1.90	.12	579	6.15
1903	237	36.02	1.48	49	7.45	.31	229	34.80	1.43	52	12.46	.51	19	2.89	.12	17	2.58	.11	25	3.80	.16	658	4.12
1904	251	47.18	1.65	54	10.15	.36	80	15.04	.53	85	15.98	.56	19	3.57	.12	30	5.64	.20	13	2.44	.09	532	3.51
1905	189	41.09	1.81	33	7.17	.32	154	33.48	1.47	46	10.00	.44	20	4.35	.19	7	1.52	.07	11	2.39	.10	460	4.40
1906	194	43.30	1.69	41	9.15	.36	107	23.88	.93	62	13.84	.54	15	3.35	.13	11	2.46	.09	18	4.02	.16	448	3.90
1907	206	40.15	1.72	38	7.34	.31	137	26.45	1.13	34	6.56	.28	75	14.48	.62	10	1.93	.08	16	3.09	.13	518	4.37
1908	210	43.30	1.71	52	10.72	.42	82	16.91	.67	29	5.98	.23	92	18.97	.75	11	2.27	.09	9	1.85	.07	485	3.94
1909	263	53.67	2.43	47	9.59	.43	82	16.74	.76	41	8.37	.38	34	6.94	.31	5	1.02	.05	18	3.67	.17	490	4.55
1910	281	32.90	2.09	65	7.61	.48	381	44.61	2.83	53	6.09	.39	42	4.92	.31	14	1.64	.10	19	2.23	.14	854	6.34
1911	218	35.73	1.78	60	9.84	.47	243	39.84	1.92	26	4.26	.21	33	5.41	.26	10	1.64	.08	20	3.28	.16	610	4.82
1912	93	38.27	1.22	25	10.29	.33	81	33.33	1.06	17	7.00	.22	17	7.00	.22	4	1.64	.05	6	2.47	.08	243	3.18
1913	74	17.54	1.09	28	6.64	.41	276	65.40	4.08	18	4.27	.27	12	2.84	.18	5	1.18	.07	9	2.13	.13	422	6.23
Total	3,796	41.69	1.70	783	8.59	.35	2,680	29.40	1.20	739	8.11	.33	616	6.76	.28	231	2.53	.11	289	2.85	.12	9,116	4.09

TABLE 75.—FATALITIES, BY CAUSES, AT BITUMINOUS COAL MINES IN THE UNITED STATES IN WHICH LESS THAN 20 PER CENT OF THE COAL WAS MINED BY MACHINES, GROUP I.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1896	247	50	54	11	65	33	3	2	....	1	....	15	481	8	1	8	.....	17	3	.....	1	3	.....	7	14	512
1897	249	61	44	14	31	31	1	2	2	....	8	8	451	10	2	6	1	19	2	.....	2	7	3	5	19	489
1898	197	31	49	15	8	26	2	1	....	....	1	5	335	7	.....	7	.....	14	8	.....	4	1	3	5	21	376
1899	152	30	31	36	33	29	1	5	....	....	....	8	325	6	1	3	1	11	5	.....	1	1	3	6	16	352
1900	223	30	36	68	205	59	3	1	2	....	7	21	655	5	5	7	.....	17	8	.....	1	1	4	4	18	690
1901	120	25	34	36	45	32	....	2	1	2	46	36	379	6	3	10	.....	19	1	.....	.....	2	1	2	6	404
1902	147	18	43	12	249	37	1	1	....	....	14	36	558	5	3	2	.....	10	4	.....	3	2	1	1	11	579
1903	213	24	49	224	5	82	....	3	1	....	3	12	616	10	2	4	1	17	10	.....	2	2	5	6	25	658
1904	219	32	54	29	51	85	2	2	....	....	....	15	489	13	3	14	.....	30	1	.....	4	1	3	4	13	532
1905	173	16	33	37	117	46	1	6	....	....	....	13	443	6	.....	1	.....	7	4	.....	.....	.....	3	4	11	465
1906	177	17	41	99	8	62	....	8	....	....	....	7	419	7	2	2	.....	11	8	.....	7	.....	.....	3	18	448
1907	188	20	38	37	100	34	....	8	....	....	10	57	492	4	.....	6	.....	10	7	1	1	1	3	3	16	518
1908	188	22	52	18	64	29	1	15	3	....	29	44	465	5	1	5	.....	11	2	.....	1	1	1	4	9	485
1909	228	35	47	56	26	41	4	12	1	....	2	15	467	1	1	3	.....	5	9	.....	2	.....	3	4	18	490
1910	241	40	65	79	302	52	....	12	1	....	10	19	821	9	.....	2	3	14	9	.....	3	1	1	5	19	854
1911	197	21	60	10	233	26	5	16	....	1	3	8	580	4	.....	4	2	10	6	.....	1	2	5	6	20	616
1912	71	22	25	76	5	17	1	5	....	....	11	....	233	.....	.....	1	3	4	1	.....	.....	.....	1	4	6	243
1913	71	3	28	8	268	18	2	3	1	....	1	5	408	2	.....	3	.....	5	3	1	1	.....	2	2	9	422
Total	3,301	497	783	865	1,815	739	27	104	12	4	135	334	8,616	108	24	88	11	231	91	2	34	25	42	75	269	9,116

TABLE 76.—PRODUCTION, MEN EMPLOYED, AND NUMBER KILLED IN AND ABOUT THE BITUMINOUS COAL MINES IN THE UNITED STATES IN WHICH 20 TO 39 PER CENT OF THE COAL WAS MINED BY MACHINES, 1896 TO 1913, INCLUSIVE, GROUP II.

(See figs. 9, 12, and 13.)

Year.	Grand totals, Group II.			Totals for States in Group II having accident statistics.												
	Production (short tons).	Men employed.	Tons mined per man.	Production (short tons).	Percentage mined by machine.	Men employed.	Days active.	Number killed.			Number killed per 1,000 employed.			Number killed per million tons mined.	Tons mined per man.	
								Total.	In exceptional accidents.	In common accidents.	Total.	In exceptional accidents.	In common accidents.		Per year.	Per day.
1896	18,324,426	36,641	500	16,780,981	25.82	34,306	161	70	7	63	2.04	0.20	1.84	4.17	489	3.04
1897	24,153,642	48,930	494	19,950,206	30.91	43,279	158	67	.....	67	1.55	.....	1.55	3.36	461	2.92
1898	88,490,651	123,182	718	88,490,651	27.67	123,182	211	274	8	266	2.22	.06	2.16	3.10	718	3.40
1899	112,458,286	140,661	799	110,253,686	28.74	138,491	238	372	29	343	2.69	.21	2.48	3.37	796	3.34
1900	87,305,770	106,442	820	87,175,887	33.07	106,116	237	293	.....	293	2.76	.....	2.76	3.36	822	3.47
1901	140,790,726	187,967	749	140,624,125	29.89	187,687	223	565	29	536	3.01	.15	2.86	4.02	749	3.36
1902	166,722,219	213,744	780	166,495,708	30.35	213,342	232	728	140	588	3.41	.66	2.75	4.37	780	3.36
1903	150,787,143	202,190	746	150,787,143	34.17	202,190	225	621	17	604	3.07	.08	2.99	4.12	746	3.32
1904	149,067,543	213,636	698	143,858,987	34.12	207,976	195	731	189	542	3.52	.91	2.61	5.08	692	3.55
1905	95,513,969	142,064	672	95,196,427	28.44	141,438	196	488	133	355	3.45	.94	2.51	5.13	673	3.43
1906	104,649,035	144,311	725	98,209,352	32.40	137,889	199	474	92	382	3.44	.67	2.77	4.83	712	3.58
1907	122,031,050	156,921	778	121,683,290	32.88	156,259	223	1,018	512	506	6.51	3.28	3.23	8.37	779	3.49
1908	97,892,526	139,128	704	93,633,484	35.30	132,920	187	513	68	445	3.86	.51	3.35	5.48	704	3.76
1909	70,567,525	100,930	699	70,567,525	31.64	100,930	188	556	293	263	5.51	2.90	2.61	7.88	699	3.72
1910	55,329,213	83,746	661	55,329,213	37.75	83,746	171	212	14	198	2.53	.17	2.36	3.83	661	3.87
1911	17,088,517	20,849	820	17,088,517	34.33	20,849	240	115	5	110	5.52	.24	5.28	6.73	820	3.42
1912	42,334,379	57,415	737	42,334,379	25.27	57,415	232	281	36	245	4.89	.62	4.27	6.64	737	3.18
1913	41,373,914	61,853	669	41,373,914	24.69	61,853	234	297	61	236	4.80	.99	3.81	7.18	669	2.86
Total	1,584,880,534	2,180,510	727	1,559,863,477	31.45	2,149,883	212	7,675	1,633	6,042	3.57	.76	2.81	4.92	726	3.42

TABLE 77.—PERCENTAGE OF FATALITIES AND RATE PER 1,000 MEN EMPLOYED, BY PRINCIPAL CAUSES AT BITUMINOUS COAL MINES IN THE UNITED STATES IN WHICH 20 TO 39 PER CENT OF THE COAL WAS MINED BY MACHINES, GROUP II.

(See fig. 11.)

Year.	Falls of roof and pillar coal. (1 and 2)			Mine cars and locomotives. (3)			Gas and dust explosions. (4 and 5)			Explosives. (6)			Miscellaneous underground. (7 to 12)			Total shaft fatalities. (13 to 16)			Total surface fatalities. (17 to 22)			Grand total.	
	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.
1896	40	57.14	1.17	8	11.43	0.23	10	14.29	0.29	4	5.71	0.12	1	1.43	0.03	6	8.57	0.17	1	1.43	0.03	70	2.06
1897	44	65.67	1.01	6	8.95	.14	2	2.99	.05	9	13.43	.21	1	1.49	.02	3	4.48	.07	2	2.99	.05	67	1.55
1898	182	66.42	1.48	35	12.77	.28	12	4.38	.10	14	5.11	.11	12	4.38	.10	7	2.55	.05	12	4.38	.10	274	2.22
1899	223	59.94	1.61	49	13.17	.36	34	9.14	.25	25	6.72	.18	15	4.03	.11	13	3.50	.09	13	3.50	.09	372	2.69
1900	183	62.46	1.72	41	13.99	.39	6	2.05	.06	14	4.78	.13	14	4.78	.13	21	7.16	.20	14	4.78	.13	293	2.78
1901	343	60.71	1.83	78	13.80	.41	39	6.90	.21	39	6.90	.21	24	4.25	.13	21	3.72	.11	21	3.72	.11	565	3.01
1902	373	51.24	1.75	87	11.95	.41	149	20.46	.70	46	6.32	.22	20	2.75	.09	33	4.53	.15	20	2.75	.09	728	3.41
1903	383	61.68	1.90	88	14.17	.44	29	4.67	.14	45	7.24	.22	27	4.35	.13	17	2.74	.08	32	5.15	.16	621	3.07
1904	365	49.93	1.76	76	10.40	.37	186	25.44	.89	20	2.74	.10	28	3.83	.13	24	3.28	.12	32	4.38	.15	731	3.52
1905	209	42.83	1.48	47	9.63	.33	125	25.61	.88	44	9.02	.31	25	5.12	.18	18	3.69	.13	20	4.10	.14	488	3.45
1906	224	47.26	1.62	44	9.28	.32	98	20.67	.71	29	6.12	.21	11	2.32	.08	37	7.81	.27	31	6.54	.23	474	3.44
1907	277	27.21	1.77	91	8.94	.58	495	48.63	3.17	72	7.07	.46	20	1.96	.13	19	1.87	.12	44	4.32	.28	1,018	6.51
1908	246	47.95	1.85	68	13.26	.51	63	12.28	.48	51	9.94	.38	30	5.85	.23	19	3.70	.14	36	7.02	.27	513	3.86
1909	138	24.82	1.37	27	4.86	.27	45	8.09	.44	44	7.91	.44	279	50.18	2.76	11	1.98	.11	12	2.16	.12	556	5.51
1910	116	54.72	1.38	34	16.04	.41	18	8.49	.21	9	4.25	.11	14	6.60	.17	13	6.13	.15	8	3.77	.10	212	2.53
1911	69	60.00	3.31	24	20.87	1.15	6	5.22	.29	4	3.48	.19	3	2.61	.15	.....	.....	.....	9	7.82	.43	115	5.52
1912	147	52.31	2.56	37	13.17	.64	53	18.86	.92	8	2.85	.14	23	7.83	.38	8	2.85	.14	6	2.13	.11	281	4.89
1913	161	54.21	2.60	34	11.45	.55	53	17.84	.86	9	3.03	.14	32	10.77	.52	1	.34	.02	7	2.36	.11	297	4.80
Total	3,723	48.51	1.73	874	11.39	.41	1,423	18.54	.66	486	6.33	.23	578	7.53	.27	271	3.53	.12	320	4.17	.15	7,675	3.57

TABLE 78.—FATALITIES, BY CAUSES, AT BITUMINOUS COAL MINES IN THE UNITED STATES IN WHICH 20 TO 39 PER CENT OF THE COAL WAS MINED BY MACHINES, GROUP II.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	Grand total.
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1896	33	7	8	10	.....	4	....	1	ad.	.....	.....	.....	63	2	....	4	....	6	1	.....	.....	.....	.....	.....	1	70
1897	39	5	6	....	2	9	....	1	....	.....	.....	.....	62	1	....	1	1	3	.....	.....	.....	1	1	.....	2	67
1898	155	27	35	12	.....	14	1	3	....	2	3	3	255	2	2	3	....	7	2	.....	3	1	4	2	12	274
1899	191	32	49	34	.....	25	....	6	....	2	....	7	346	4	2	5	2	13	2	.....	4	2	2	3	13	372
1900	148	35	41	6	.....	14	1	6	....	1	1	4	258	10	2	9	....	21	10	.....	.....	.....	3	1	14	293
1901	288	55	78	38	1	39	....	9	4	2	1	8	523	7	2	12	....	21	13	.....	2	.....	3	3	21	565
1902	319	54	87	149	.....	46	....	12	1	4	....	3	675	14	2	17	....	33	8	.....	2	3	2	5	20	728
1903	329	54	88	26	3	45	....	12	2	2	1	10	572	12	1	4	....	17	18	.....	2	1	7	4	32	621
1904	318	47	76	7	179	20	....	16	....	2	1	9	675	11	1	12	....	24	14	.....	4	1	7	6	32	731
1905	187	22	47	78	47	44	....	2	2	....	14	7	450	7	1	10	....	18	6	.....	3	.....	9	2	20	488
1906	194	30	44	30	68	29	....	7	....	1	....	3	406	18	3	16	....	37	12	.....	2	1	6	10	31	474
1907	229	48	91	32	463	72	....	6	3	1	....	10	955	9	5	5	....	19	12	.....	5	.....	11	16	44	1,018
1908	191	55	68	4	59	51	....	11	3	2	10	4	458	16	1	2	....	19	12	5	4	.....	10	5	36	513
1909	101	37	27	45	.....	44	....	4	2	....	250	14	533	1	1	9	....	11	.....	.....	2	1	5	4	12	556
1910	100	16	34	8	10	9	....	4	5	3	....	2	191	4	3	6	....	13	1	.....	.....	1	5	1	8	212
1911	57	12	24	6	.....	4	....	2	....	.....	.....	1	106	.....	.....	.....	.....	.....	5	.....	.....	.....	.....	4	9	115
1912	124	23	37	43	10	8	....	17	1	.....	.....	4	267	3	1	4	....	8	2	.....	.....	.....	4	.....	6	281
1913	144	17	34	3	50	9	14	8	1	3	1	5	289	....	....	1	....	1	1	.....	1	.....	2	3	7	297
Total	3,147	576	874	531	892	486	16	127	25	25	291	94	7,084	121	27	120	3	271	119	5	34	12	81	29	280	7,675

TABLE 79.—PRODUCTION, MEN EMPLOYED, AND NUMBER KILLED IN AND ABOUT THE BITUMINOUS COAL MINES IN THE UNITED STATES IN WHICH 40 TO 59 PER CENT OF THE COAL WAS MINED BY MACHINES, 1896 TO 1913, INCLUSIVE, GROUP III.

[See figs. 9, 12, and 13.]

Year.	Grand totals, Group III.			Totals for States in Group III having accident statistics.											
								Number killed.			Number killed per 1,000 employed.			Number killed per million tons mined.	Tons mined per man.	
	Production (short tons).	Men employed.	Tons mined per man.	Production (short tons).	Percentage mined by machine.	Men employed.	Days active.	Total.	In exceptional accidents.	In common accidents.	Total.	In exceptional accidents.	In common accidents.		Per year.	Per day.
1896																
1897	1,647,882	2,337	705	1,647,882	43.70	2,337	252	11	.....	11	4.71	.....	4.71	6.68	705	2.80
1898	1,479,803	2,359	627	1,479,803	46.06	2,359	216	7	.....	7	2.97	.....	2.97	4.73	627	2.90
1899	17,996,721	28,416	633	16,500,270	41.35	26,038	200	56	.....	56	2.15	.....	2.15	3.39	634	3.17
1900	24,317,114	37,308	652	24,317,114	45.96	37,308	218	88	.....	88	2.36	.....	2.36	3.62	652	2.99
1901	27,809,874	44,576	624	27,809,874	46.43	44,576	203	92	.....	92	2.06	.....	2.06	3.31	624	3.07
1902	31,847,701	54,630	583	31,847,701	49.86	54,630	205	117	.....	117	2.14	.....	2.14	3.67	583	2.84
1903	26,605,558	44,577	597	26,326,913	56.28	44,091	197	129	.....	129	2.93	.....	2.93	4.90	597	3.03
1904	32,248,630	58,423	552	31,976,702	54.97	57,869	180	137	5	132	2.37	0.09	2.28	4.28	553	3.07
1905	128,489,992	160,495	801	128,489,992	42.04	160,495	228	514	37	477	3.20	.23	2.97	4.00	801	3.51
1906	140,776,774	169,765	829	140,776,774	42.83	169,765	229	528	15	513	3.11	.09	3.02	3.75	829	3.62
1907	162,913,158	183,001	890	162,913,158	41.28	183,001	251	844	278	566	4.61	1.52	3.09	5.18	890	3.55
1908	139,740,970	201,337	694	139,740,970	45.80	201,337	197	656	174	482	3.26	.87	2.39	4.69	694	3.52
1909	204,650,270	235,691	868	204,650,270	41.91	235,691	238	885	125	760	3.75	.53	3.22	4.32	868	3.65
1910	232,516,368	270,053	861	232,516,368	45.73	270,053	234	909	22	887	3.37	.08	3.29	3.91	861	3.68
1911	273,749,384	337,803	810	273,749,384	47.17	337,803	217	1,081	93	988	3.20	.28	2.92	3.95	810	3.73
1912	312,875,987	344,932	907	312,875,987	49.93	344,932	236	1,108	117	991	3.21	.34	2.87	3.54	907	3.84
1913	340,591,068	366,880	928	340,591,068	53.36	366,880	238	1,232	101	1,131	3.36	.28	3.08	3.62	928	3.90
Total	2,100,257,254	2,542,583	826	2,098,210,230	46.96	2,539,165	227	8,394	967	7,427	3.31	.38	2.92	4.00	826	3.64

TABLE 80.—PERCENTAGE OF FATALITIES AND RATE PER 1,000 MEN EMPLOYED, BY PRINCIPAL CAUSES AT BITUMINOUS COAL MINES IN THE UNITED STATES IN WHICH 40 TO 59 PER CENT OF THE COAL WAS MINED BY MACHINES, GROUP III.

[See fig. 11.]

Year.	Falls of roof and pillar coal. (1 and 2)			Mine cars and locomotives. (3)			Gas and dust explosions. (4 and 5)			Explosives. (6)			Miscellaneous underground. (7 to 12)			Total shaft fatalities. (12 to 16)			Total surface fatalities. (13 to 16)			Grand total.	
	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.
1896																							
1897	6	54.55	2.57	5	45.45	2.14																11	4.71
1898	5	71.42	2.11							1	14.29	0.43	1	14.29	0.43							7	2.97
1899	40	71.43	1.54	4	7.14	.15				4	7.14	.15	1	1.79	.04	4	7.14	.15	3	5.36	.12	56	2.15
1900	58	65.90	1.55	16	18.18	.43	3	3.41	.08	4	4.55	.11				4	4.55	.11	3	3.41	.08	88	2.36
1901	47	51.09	1.05	15	16.30	.34	3	3.26	.07	12	13.04	.27	6	6.52	.13	4	4.35	.09	5	5.44	.11	92	2.06
1902	73	62.39	1.34	14	11.97	.26	3	2.56	.05	16	13.68	.29	7	5.98	.13	1	.86	.02	3	2.56	.05	117	2.14
1903	91	70.54	2.07	14	10.85	.32	4	3.10	.09	11	8.53	.25	4	3.10	.09	4	3.10	.09	1	.78	.02	129	2.93
1904	81	59.12	1.40	14	10.22	.24	5	3.65	.09	16	11.68	.28	9	6.57	.15	5	3.65	.09	7	5.11	.12	137	2.37
1905	325	63.23	2.02	69	13.43	.43	36	7.00	.22	25	4.86	.16	24	4.67	.15	8	1.56	.05	27	5.25	.17	514	3.20
1906	328	62.12	1.93	92	17.43	.54	11	2.08	.06	12	2.27	.07	45	8.52	.27	15	2.84	.09	25	4.74	.15	528	3.11
1907	328	38.86	1.79	110	13.03	.60	276	32.70	1.51	24	2.85	.13	39	4.62	.21	29	3.44	.16	38	4.50	.21	844	4.61
1908	299	45.58	1.49	85	12.96	.42	173	26.37	.86	23	3.51	.12	29	4.42	.14	21	3.20	.10	26	3.96	.13	656	3.26
1909	486	54.92	2.06	139	15.71	.59	127	14.35	.54	26	2.93	.11	49	5.54	.21	20	2.26	.08	38	4.29	.16	885	3.75
1910	542	59.63	2.01	167	18.37	.62	22	2.42	.08	31	3.41	.12	62	6.82	.23	30	3.30	.11	55	6.05	.20	909	3.37
1911	606	56.06	1.80	190	17.58	.56	82	7.58	.24	35	3.24	.10	95	8.79	.28	21	1.94	.06	52	4.81	.16	1,081	3.20
1912	584	52.71	1.69	209	18.86	.61	109	9.84	.32	39	3.52	.11	71	6.41	.20	23	2.07	.07	73	6.59	.21	1,108	3.21
1913	652	52.92	1.78	244	19.81	.66	120	9.74	.33	29	2.35	.08	94	7.63	.26	18	1.46	.05	75	6.09	.20	1,232	3.36
Total	4,551	54.22	1.79	1,387	16.52	.55	974	11.60	.39	368	3.67	.12	536	6.39	.21	207	2.47	.08	431	5.13	.17	8,394	3.31

TABLE 31.—FATALITIES, BY CAUSES, AT BITUMINOUS COAL MINES IN THE UNITED STATES IN WHICH 40 TO 59 PER CENT OF THE COAL WAS MINED BY MACHINES, GROUP III.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1896																										
1897	3	3	5										11													11
1898	1	4				1						1	7													7
1899	34	6	4			4		1					49			4		4					2	1	3	56
1900	52	6	16	3		4							81	3		1		4					1	2	3	92
1901	39	8	15	3		12	1	1				4	83	1	2	1		4			1	3	1		5	96
1902	66	7	14	3		16						7	113			1		1	1	1		1			3	117
1903	79	12	14	4		11		2		1		1	124	1	1	2		4	1						1	129
1904	70	11	14		5	16	1	2		5		1	125	4	1			5	3				1	3	7	137
1905	283	42	69	23	13	25	2	9	2	2	6	3	479	5	1	2		8	6	1	1	1	12	6	27	514
1906	288	40	92	11		12	1	28	1	5	8	2	488	7	3	4	1	15	9	2	4		3	7	25	528
1907	289	39	110	37	239	24		25	1	5	1	7	777	15	2	12		29	12		7	1	5	13	38	844
1908	260	39	85	10	163	23		22	1	4		2	609	5	2	14		21	15	1	2	2	3	3	26	656
1909	415	71	139	13	114	26		33	1	2	3	10	827	10	3	7		20	16	2	6		4	10	38	885
1910	464	78	167	22		31		51	2	6		3	824	14		16		30	26	2	7	5	4	11	55	909
1911	498	108	190	49	33	35	1	68	4	5		17	1,008	13		8		21	23	4	7	4	4	10	52	1,081
1912	504	80	209	24	85	39		46	3	5		17	1,012	11	2	10		23	31	6	9	3	7	17	73	1,108
1913	537	115	244	15	105	29	1	55	3	13	2	20	1,139	12	1	4	1	18	38	6	9	1	3	18	75	1,232
Total	3,982	669	1,987	217	757	308	7	343	18	53	20	95	7,756	101	16	86	2	207	181	25	53	21	50	101	431	8,394

TABLE 82.—PRODUCTION, MEN EMPLOYED, AND NUMBER KILLED IN AND ABOUT THE BITUMINOUS COAL MINES IN THE UNITED STATES IN WHICH 60 PER CENT AND OVER OF THE COAL WAS MINED BY MACHINES, 1896 TO 1913, INCLUSIVE, GROUP IV.

[See figs. 9, 12, and 13.]

Year.	Grand totals, Group IV.			Totals for States in Group IV having accident statistics.													
	Production (short tons).	Men employed.	Tons mined per man.	Production (short tons).	Percentage mined by machine.	Men employed.	Days active.	Number killed.			Number killed per 1,000 employed.			Number killed per million tons mined.	Tons mined per man.	
								Total.	In exceptional accidents.	In common accidents.	Total.	In exceptional accidents.	In common accidents.		Per year.	Per day.
1896																
1897																
1898	88,895	151	556													
1899																
1900	1,661,775	2,376	699	1,661,775	62.90	2,376	252	7	.....	7	2.95	.....	2.95	4.21	699	2.77
1901																
1902																
1903																
1904																
1905	25,552,950	43,399	589	25,552,950	66.10	43,399	176	126	.....	126	2.90	.....	2.90	4.93	589	3.35
1906	27,731,640	45,438	610	27,731,640	72.14	45,438	167	131	5	126	2.88	0.11	2.77	4.72	610	3.65
1907	32,142,419	46,833	686	32,142,419	77.30	46,833	199	154	.....	154	3.29	.....	3.29	4.79	686	3.45
1908	26,270,639	47,407	554	26,270,639	75.37	47,407	161	113	.....	113	2.38	.....	2.38	4.30	554	3.44
1909	38,637,025	55,017	702	38,637,025	74.04	55,017	208	144	7	137	2.62	.13	2.49	3.73	702	3.46
1910	48,832,987	66,957	729	48,832,987	73.32	66,957	208	245	65	180	3.66	.97	2.69	5.02	729	3.50
1911	44,809,689	69,583	644	44,809,689	79.77	69,583	187	151	.....	151	2.17	.....	2.17	3.37	644	3.44
1912	51,019,248	69,831	731	51,019,248	80.36	69,831	201	186	10	176	2.66	.14	2.52	3.65	731	3.64
1913	57,048,913	75,452	756	57,048,913	83.89	75,452	207	216	20	196	2.86	.26	2.60	3.79	756	3.65
Total	353,791,180	522,444	677	353,707,285	77.48	522,293	192	1,473	107	1,366	2.82	.20	2.62	4.16	677	3.53

TABLE 83.—PERCENTAGE OF FATALITIES AND RATE PER 1,000 MEN EMPLOYED, BY PRINCIPAL CAUSES AT BITUMINOUS COAL MINES IN THE UNITED STATES IN WHICH 60 PER CENT AND OVER OF THE COAL WAS MINED BY MACHINES, GROUP IV.

(See fig. 11.)

Year.	Falls of roof and pillar coal. (1 and 20)			Mine cars and locomotives. (3)			Gas and dust explosions. (4 and 5)			Explosives. (6)			Miscellaneous underground. (7 to 12)			Total shaft fatalities. (13 to 16)			Total surface fatalities. (17 to 22)			Grand total.	
	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.	Number killed.	Number killed per 1,000 employed.
1896																							
1897																							
1898																							
1899																							
1900	4	57.14	1.69	1	14.29	0.42				2	28.57	0.84										7	2.96
1901																							
1902																							
1903																							
1904																							
1905	78	61.91	1.80	16	12.70	.37	1	0.79	0.02	4	3.17	0.09	11	8.73	0.25	3	2.38	0.07	13	10.32	0.30	126	2.90
1906	80	61.07	1.76	12	9.16	.26	3	2.29	.07	12	9.16	.26	11	8.40	.24	10	7.63	.22	3	2.29	.07	131	2.83
1907	98	63.63	2.09	17	11.04	.36	3	1.95	.06	4	2.60	.09	18	11.69	.39	1	.65	.02	13	8.44	.28	154	3.29
1908	74	65.49	1.56	17	15.04	.35	2	1.77	.04	6	5.31	.13	6	5.31	.13	2	1.77	.04	6	5.31	.13	113	2.35
1909	88	61.11	1.60	23	15.97	.42	10	6.95	.18	11	7.64	.20	6	4.17	.11	1	.69	.02	5	3.47	.09	144	2.62
1910	122	49.80	1.82	21	8.57	.31	56	22.86	.84	21	8.57	.31	12	4.90	.18	3	1.22	.05	10	4.08	.15	245	3.66
1911	114	75.50	1.64	16	10.60	.23				7	4.63	10	9	5.96	.13				5	3.31	.07	151	2.17
1912	119	63.98	1.70	21	11.29	.30	12	6.45	.17	6	3.23	.08	13	6.99	.19	4	2.15	.06	11	5.91	.16	186	2.66
1913	120	55.56	1.59	33	15.28	.44	15	6.94	.20	7	3.24	.09	28	12.96	.37	8	3.70	.10	5	2.32	.07	216	2.86
Total	897	60.90	1.72	177	12.02	34	102	6.92	.19	80	5.43	.15	114	7.74	.22	32	2.17	.06	71	4.82	.14	1,473	2.82

TABLE 84.—FATALITIES, BY CAUSES, AT BITUMINOUS COAL MINES IN THE UNITED STATES IN WHICH 60 PER CENT AND OVER OF THE COAL WAS MINED BY MACHINES, GROUP IV.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1896	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1897	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....
1898	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1899	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1900	1	3	1	.....	.....	2	.....	.....	.....	.....	.....	.....	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7
1901	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1902	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1903	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1904	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1905	71	7	16	1	.....	4	.....	6	.....	4	.....	1	110	1	.....	2	.....	3	2	.....	1	4	1	5	13	126
1906	75	5	12	3	.....	12	.....	9	2	.....	.....	.....	118	1	1	8	.....	10	3	.....	.....	.....	.....	.....	3	131
1907	95	3	17	3	.....	4	.....	10	.....	3	.....	5	140	1	.....	.....	.....	1	3	1	2	3	4	.....	13	154
1908	71	3	17	2	.....	6	.....	5	.....	1	.....	.....	105	1	1	.....	.....	2	1	.....	.....	.....	1	4	6	113
1909	86	2	23	8	2	11	.....	3	.....	3	.....	.....	138	1	.....	.....	.....	1	2	.....	.....	.....	1	2	5	144
1910	114	8	21	16	40	21	.....	9	.....	2	.....	1	232	1	.....	2	.....	3	6	.....	1	1	2	.....	10	245
1911	106	8	16	.....	.....	7	.....	6	.....	3	.....	.....	146	.....	.....	.....	.....	.....	1	.....	1	.....	3	.....	5	151
1912	110	9	21	7	5	6	.....	7	.....	2	.....	4	171	1	.....	3	.....	4	3	.....	2	.....	2	4	11	186
1913	116	4	33	15	.....	7	5	13	.....	4	.....	6	203	6	.....	1	1	8	1	.....	.....	.....	1	3	5	216
Total	845	53	177	55	47	80	5	68	2	22	....	17	1,370	13	2	16	1	32	22	1	7	8	15	18	71	1,473

PART II.—COAL-MINE STATISTICS FOR EACH STATE BY CALENDAR YEARS.

INTRODUCTION.

The following pages give detailed information of the coal-mining industry by States, arranged in alphabetical order, and calendar years. Most of the information has a bearing on the accident hazard. Comments are made on the coal-bearing area of each State, the character of the coal beds, that is, whether the beds are thick or thin, flat or inclined, and data are given concerning the roof conditions. There are also notes on the methods of mining, whether long-wall, room-and-pillar, etc., with statements as to whether the coal is mined by hand, machine, or shot off the solid.

In the State tables are complete figures for the production of coal from the beginning of the industry to the end of 1914; also the number of men employed, the number of fatalities, and the fatality rates per 1,000 men employed and per million tons of coal produced since the beginning of inspection service. The tables also give the number of days the mines were operated each year, the number of tons of coal mined per man, per day, and per year, together with the number of mining machines in use since 1891, or since their introduction into the mines, if adopted at a later date.

There is also for each State one table showing all the fatalities by causes and calendar years, for which complete records are available, and with this as a start it should be an easy matter for each State to continue its records on the calendar-year basis. There will also be found under each State data as to the number of hours worked per day and the number of men employed in each group of 8, 9, or 10 hour workers. Fatality rates have also been calculated on the basis of a uniform year of 2,000 hours, so that true comparisons of one State with another may be readily made. Under each State will also be found a list of all of the mine disasters in which five or more men were killed at one time. The last table under each State gives data concerning strikes and lockouts, showing the number of men involved and the total amount of time lost.

While the area of the coal fields will be found under each State, the accompanying table shows, in addition, the estimated original supply, the production in 1913, and the total production to the close of 1913; and in the last column is shown the estimated available supply of coal in the various States at the close of 1913 as estimated by the United States Geological Survey.

AREAS OF THE COAL FIELDS BY STATES, ESTIMATES OF ORIGINAL AND PRESENT SUPPLY, AND THE PRODUCTION TO THE CLOSE OF 1913.[a]

	Area.	Estimated original supply.	Production in 1913.	Total production to close of 1913.	Total exhaustion to close of 1913.	Estimated available supply.
ANTHRACITE.	*Square miles.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
Pennsylvania	480	21,000,000,000	91,524,922	2,446,696,010	4,847,000,000	16,153,000,000
Colorado and New Mexico	(b)	(b)	(b)			
Total	480	21,000,000,000	91,524,922	2,446,696,010	4,847,000,000	16,153,000,000
BITUMINOUS.[c]						
Eastern province.						
Atlantic coast region:						
Virginia	150	(d)	(d)	(d)	(d)	(d)
North Carolina	60	200,000,000		477,125	715,700	199,284,300
Appalachian region:						
Pennsylvania	14,200	112,574,000,000	173,781,217	2,731,945,059	4,100,000,000	108,474,000,000
Ohio	12,660	93,967,900,000	36,200,527	682,678,546	1,024,000,000	92,943,900,000
Maryland	455	8,044,000,000	4,779,839	175,653,679	263,500,000	7,780,500,000
Virginia	1,750	22,500,000,000	8,828,068	96,287,781	134,500,000	22,365,500,000
West Virginia	17,000	151,544,900,000	71,308,982	787,543,870	1,181,300,000	150,363,600,000
Eastern Kentucky	10,270	67,787,000,000	11,098,960	93,423,911	140,000,000	67,647,000,000
Tennessee	4,400	25,665,000,000	6,903,784	123,798,965	186,000,000	25,479,000,000
Georgia	167	933,000,000	255,626	9,425,298	14,200,000	918,800,000
Alabama	8,455	67,583,000,000	17,678,522	254,954,358	382,400,000	67,200,600,000
Total	69,357	550,598,800,000	330,835,525	4,955,706,467	7,425,900,000	543,172,900,000
Interior province.						
Northern region:						
Michigan	11,000	12,000,000,000	1,231,786	22,911,711	34,400,000	11,965,600,000
Eastern region:						
Indiana	6,500	53,051,000,000	17,165,671	251,632,098	377,500,000	52,673,500,000
Western Kentucky	6,400	55,540,000,000	8,517,640	114,704,743	172,000,000	55,368,000,000
Illinois	35,600	201,399,800,000	61,618,744	965,516,323	1,448,300,000	199,951,500,000
Total	48,500	309,990,800,000	87,302,055	1,331,853,164	1,997,800,000	307,993,000,000

[a] Mineral Resources, U. S. Geological Survey, 1913.
[b] Included in Rocky Mountain and Northern Great Plains provinces.
[c] Includes brown coal or lignite, semianthracite, semibituminous, etc., and scattering lots of anthracite.
[d] Included in production of Appalachian region.

AREAS OF THE COAL FIELDS BY STATES, ESTIMATES OF ORIGINAL AND PRESENT SUPPLY, AND THE PRODUCTION TO THE CLOSE OF 1913—Contd.

	Area.	Estimated original supply.	Production in 1913.	Total production to close of 1913.	Total exhaustion to close of 1913.	Estimated available supply.
BITUMINOUS—*continued.*						
Interior province—Continued.						
Western and southwestern regions: [a]	*Square miles.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
Iowa	12,560	29,160,000,000	7,525,936	186,603,097	280,000,000	28,880,000,000
Missouri	23,960	84,000,000,000	4,318,125	120,168,472	180,000,000	83,820,000,000
Kansas	18,600	30,000,000,000	7,202,210	129,696,761	194,500,000	29,805,500,000
Arkansas	7,580	1,887,000,000	2,234,107	36,559,588	55,000,000	1,832,000,000
Oklahoma	10,000	54,951,500,000	4,165,770	59,474,164	89,200,000	54,862,300,000
Texas	68,500	31,000,000,000	2,429,144	26,649,290	40,000,000	30,960,000,000
Total	141,200	230,998,500,000	27,875,292	559,151,372	838,700,000	230,159,800,000
Rocky Mountain and Northern Great Plains provinces.						
Arizona	3,610	14,151,400,000				14,151,400,000
North Dakota	35,980	697,929,400,000	495,320	5,423,516	8,200,000	697,921,200,000
Montana	39,532	381,115,800,000	3,240,973	41,400,059	62,000,000	381,053,800,000
South Dakota	10,980	1,020,300,000				1,020,300,000
Wyoming	41,540	670,723,100,000	7,393,066	118,740,918	178,000,000	670,545,100,000
Utah	11,176	88,345,500,000	3,254,828	34,252,834	51,400,000	88,294,100,000
Colorado	19,754	317,852,600,000	9,232,510	175,361,698	263,000,000	317,589,600,000
New Mexico	14,220	191,840,100,000	3,708,806	41,496,606	62,200,000	191,777,900,000
Idaho	1,230	700,000,000	[b] 2,177	48,623	73,000	699,927,000
Total	178,022	2,363,678,200,000	27,327,680	316,724,254	624,873,000	2,363,053,327,000
Pacific coast province and Alaska						
Washington	1,800	63,873,100,000	3,877,891	64,459,440	96,700,000	63,776,400,000
Oregon	230	1,000,000,000	46,063	2,165,821	3,250,000	996,750,000
California	40	44,000,000	24,839	5,153,264	7,733,000	36,267,000
Alaska			2,072	47,969		
Total	2,070	64,917,100,000	3,950,865	71,826,494	107,683,000	64,809,417,000
Total production, including colliery consumption	[c] 450,839	3,553,383,400,000	570,048,125	9,844,247,843	15,877,071,700	3,538,506,328,300

[a] Including Arkansas and Texas lignite fields of Gulf province.
[b] Includes a little coal from Nevada.
[c] Includes 89,482 square miles supposed, but not definitely known, to contain usable coal, and 28,470 square miles in which the coal lies under cover 3,000 or more feet in thickness.

ALABAMA.

AREA AND DISTRIBUTION OF COAL FIELDS.

The Alabama coal fields form the southwestern end of the Appalachian coal region, which extends from Pennsylvania to Alabama. There are four distinct fields: The Coosa field, on the southeast; the Cahaba field, somewhat west of the Coosa; the Warrior field, 7 to 10 miles west of the Cahaba field; and the Plateau field, in the northeast corner of the State and northeast of the Warrior field, and not entirely separate therefrom. These fields were originally connected, but have been separated since their formation by erosion along the lines of faults or anticlines. The total remaining area is now about 8,500 square miles not including the area, probably of considerable size, beneath younger rocks to the southwest of the visible margin of the coal-bearing rocks.

COOSA FIELD.

The Coosa field, or basin, is a structural trough 6 miles wide extending for 60 miles through Shelby and St. Clair counties and containing about 260 square miles. It is faulted along its southeast margin, so that in general only the western half of the trough remains. The coal beds dip to the southeast at angles varying with the locality from 10° to 50°. However, the structure is less simple than the above description indicates, for at the north end there are a number of small subordinate basins due to local faults and folds, and in the southern two-thirds, the structure, although it is rather more regular, is affected by internal faults and folds. The conglomerate, sandstone, and shale, which comprise the coal-bearing rocks, are of great thickness, probably not less than 10,000 feet as a maximum. The best known part of the field is the northeast, where there are 18 coal beds, each of which varies considerably in thickness from place to place, the minimum thicknesses varying from zero to 2½ feet and the maximum thicknesses from 8 inches to 5 feet 8 inches. These beds lie in the small subordinate basins above mentioned and in the upper 4,000 feet of the rocks, so that their total area is probably not over one-tenth of the area of the field, say 35 square miles. In the other parts of the Coosa trough the coal beds are not so well known but appear to be few and comparatively thin. Excepting two beds the character of the Coosa coals has not been adequately determined. So far as shown by the tests made, the coal is high-grade bituminous with low sulphur and medium ash contents and of about the hardness of the southern Appalachian coals generally. One bed is reported to yield good coking coal.

CAHABA FIELD.

The Cahaba field, or basin, like the Coosa field, is a synclinal trough lying a few miles west of the Coosa field. It is about 68 miles long and extends from the northeastern part of Bibb County through Shelby County into St. Clair County, its average width is about 6 miles except in the southwest third where it expands to twice that width, and its area is about 350 square miles.

Like the Coosa field the eastern half of the Cahaba trough is faulted, except for a few miles at the south end, where the southeast limb of the syncline in a vertical or slightly overturned attitude is preserved. Along the western margin of the trough the dip varies from 10° to 60° southeast. In the north half of the field this southeast dip prevails to the fault in the southeast, but extending along the middle of the southern half of the field the southeast dip is interrupted by a high anticline with a vertical dip on the northwest limb and a dip of 40° on the southeast limb near the crest, but diminishing gradually to a low dip southeastward to the boundary fault, except for the few miles where the southeast limb of the trough is preserved. In this area the rocks bend abruptly upward and stand vertical at the surface. In addition to these major folds, there are a number of subordinate basins along the southeastern margin, caused by transverse folds with dips of all degrees up to vertical. Several faults of varying magnitude are known, but apparently faults are few.

The coal-bearing strata, conglomerate, sandstone, and shale, are about 9,000 feet thick in the southern part of the field and about 5,000 feet in the northern part.

In the southern part there are at least 17 coal beds that in some part of their extent are 2 feet or over in thickness, the thickest bed being 5 to 6 feet. Most of the beds, with the exceptions of local thinning or thickening, range from 2 to 4 feet in thickness.

The coal is high-grade bituminous with a low to medium ash content, a generally low sulphur content, and, as a rule, is of average hardness. It is said to make a good quality of coke, but the yield is lower than the Warrior coals, so that the product is all consumed as domestic, steam or gas coal.

WARRIOR FIELD.

The Warrior coal field, or basin, lies 7 to 10 miles west of the Cahaba field and extends westward nearly to the State boundary. It is a quadrangular area, including all or parts of the following counties: Jefferson, Walker, Tuscaloosa, Fayette, Marion, Franklin, Lawrence, Winston, Cullman, Morgan, and Blount. The Warrior field is not

definitely separated from the Plateau field on the northeast, and their limits have not yet been definitely defined. The combined area of the two fields is about 7,600 square miles. Along the southeast edge of the Warrior field the strata dip 90° to 40°, or less, to the west; but throughout the remainder of the field are nearly flat or gently and broadly warped. The rocks, conglomerate, sandstone, or shale are about 3,000 feet thick.

The number of workable coal beds is about fifteen. They constitute the following groups from below upward: Black Creek, Mary Lee, Pratt, and Brookwood, each named from its most important coal bed. The bottom of the Black Creek group is about 900 feet above, and the top of the Brookwood is about 2,300 feet above, the bottom of the coal-bearing rocks, so that the main coal beds extend through about 1,400 feet of strata.

The Black Creek, the lowest and most extensive bed, averages about 3 feet thick and is an excellent domestic coal, for which it is mainly used. The Mary Lee group contains five beds, but at all points one "big seam," which possibly may be everywhere the same bed, or at different points may be one or another of the five beds. This "big seam" is of great areal extent, varies from 5 to 10 feet in thickness, and includes many thin or a few thick clay partings. The Pratt group likewise contains five coal beds, of which three are important, one of the three being the Pratt bed, which over large areas is 3 to 5 feet thick, with at some places a thin parting or two and at others being all clean coal. The Brookwood group includes three or four beds, of which the Brookwood bed is the most important, being 3 to 7 feet thick. This group, being high in the coal-bearing rocks, occupies only a relatively small area in Tuscaloosa County. The "Big seam," Pratt, and Brookwood beds are the thickest in the Warrior basin. In 1899 the Pratt beds yielded 65 per cent of the total coal production from the basin, and in recent years about 33 per cent.

The average composition of 23 samples of the different coal beds of the Warrior basin is approximately as follows: 2.4 per cent moisture, 28.4 per cent volatile matter, 59 per cent fixed carbon, 10.2 per cent ash, and 1.74 per cent sulphur. It is a high-grade bituminous coal of medium hardness and a domestic steam and coking coal. Practically all the coke consumed in the State is made from coal from the "Big seam," Pratt bed, and the beds of the Brookwood group, of which the principal one is the Brookwood.

PLATEAU FIELD.

The Plateau field comprises a long belt on Sand Mountain extending from the Warrior field, with which it is continuous on the south-

west, to the northeast corner of the State, a number of detached areas to the northwest of the Sand Mountain belt, the detached area of Lookout Mountain, and the semi-detached area of Blount Mountain on the southeast of Sand Mountain. These various areas lie mainly in Madison, Jackson, DeKalb, Etowah, Marshall, and Blount Counties.

The character of the rocks is the same as in the other fields, but their thickness and the number and thickness of coal beds are not well known. There are perhaps four or six different beds, more or less local in extent, which range from 2 to 4 feet in thickness.

Except on the western edge of Blount Mountain, where the rocks are vertical, the dip is slight and in most parts of the field the rocks are nearly flat.

MINING METHODS.

Coal mining was first begun in the Coosa basin in 1836, and in the Cahaba field in 1856. General uniformity in mining methods prevails throughout the Birmingham district with the exception of slight modifications which are rendered necessary by differences in the geologic structure. In the Coosa and Cahaba basins the coal-bearing strata generally dip from 5° to 30°, but, as on the southeastern margin of the Cahaba basin, the dip is 60° or in places even 90°. Practically all of the mines are opened by slopes, the main entry following the dip of the coal. From these slopes the coal is mined by the room-and-pillar system. In the central and western parts of the Warrior field, where the coal beds are nearly flat and the coal is above the drainage levels, the mines are opened almost exclusively by drifts. Along the southeastern margin of the Warrior basin, where the dip is 40° to 90°, the mines are opened by slopes; at a few mines shafts are employed for reaching the lower coal. Shafts are also used in the southern part of the basin where the coal-bearing formations pass below the drainage level. The room-and-pillar system of mining also prevails in this part of the district. In 1899 only one mine was reported as using the long wall system, and only 3½ per cent of the output was mined by machines, whereas in 1913 the machine-mined coal amounted to 23.3 per cent. The number of machines in operation in 1899 was 53, and in 1913, 377. In 1912, 35.1 per cent of the coal was shot off the solid, and in 1913, 39.9 per cent, an increase of 5.8 per cent. Tail rope, endless rope, electric, and mule haulage are employed.

ROOF.

So far as the character of the roof is concerned, whether sandstone or shale, it is generally strong. The roof of the Thompson bed

(southern part of the Cahaba field) is of shale 10 feet thick that slakes rapidly and falls badly, so that it is necessary to put in heavy timber in the main haulage ways. A fragile shale roof is reported in a few mines.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

The office of inspector of mines of Alabama was created by an act approved February 18, 1891, applying to all coal, iron, or other mines where 20 or more men were employed underground. The inspector was appointed by the governor, and was required to examine every mine at least once every three months. By an act approved February 16, 1893, the operators were required to notify the inspector of fatal accidents, and the inspector, at the operator's request or the request of three miners, examined into the cause of such accidents, and preserved in his office a record of each accident of which he received notice. Biennial reports were rendered to the governor. The act of February 18, 1895, made it the duty of mine operators to report to the inspector serious as well as fatal accidents in and about the mines. A chief inspector and two associate mine inspectors were provided for by the act of February 16, 1897, the chief inspector to report biennially to the governor. The act of April 18, 1911, authorized the governor to appoint an inspector of coal mines for each 2½ million tons of coal mined, or majority fraction thereof, based on the output for previous years as compiled by the chief mine inspector, one of the inspectors so appointed to be designated chief inspector, and the others associate inspectors, and one of them to be a mining engineer. The law required the inspector to report to the governor before the legislature convened.

The practice of mine operators in Alabama is to report to the inspectors all accidents causing 10 days' disability. A serious injury is considered as one causing disability for 30 days, a slight injury being one which disables an employee 1 to 29 days. Only the serious injuries are published in the inspector's annual reports.

In 1915 there were one chief inspector and six district inspectors.

ACCIDENTS.

The accompanying tables show the number of fatalities by causes and calendar years since 1893 as compiled from the State mine inspectors' annual reports. These tables also show the percentage of accidents, classified by principal causes, and the fatality rate per 1,000 men employed over a period of 21 years for which continuous records

are available. The fatality rate during this period is 5.25 per 1,000 men employed. Since 1897 to the end of 1913 there have been 12 disasters in which 5 or more men were killed at one time, representing a total of 500 fatalities, or approximately 27 per cent of the total

FATALITIES IN ALABAMA COAL MINES, BY PRINCIPAL CAUSES, DURING 21 YEARS, 1893 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	713	38.31	2.01
Mine cars and locomotives	193	10.37	.55
Gas and dust explosions	620	33.32	1.75
Explosives	96	5.16	.27
Miscellaneous	203	10.91	.57
Shaft	8	.43	.02
Surface	28	1.50	.08
Total (21 years)	1,861	100.00	5.25

COAL-MINE ACCIDENTS IN ALABAMA IN WHICH 5 OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Nature of accident.	Number killed.
1897 Sept. 20	Belle-Ellen	Belle-Ellen	Mine fire	5
1899 Feb. 21	Blocton No. 2	Blocton	Mine explosion	5
1905 Feb. 20	Virginia City	Virginia City	do	108
1906 Feb. 27	Little Cahaba	Piper	do	12
1907 Dec. 16	Yolande	Yolande	do	56
1909 Feb. 2	Short Creek	Short Creek	do	16
1910 Apr. 20	Mulga	Mulga	do	40
1910 May 5	Palos No. 3	Palos	do	83
1910 Nov. 3	Yolande No. 1	Yolande	do	5
1911 Apr. 8	Banner	Littleton	do	128
1912 Aug. 13	Abernant	Abernant	do	18
1913 Nov. 18	Acton No. 2	Acton	do	24
1914 Jan. 10	Rock Castle	Rock Castle	do	12
1914 Oct. 5	Mulga	Mulga	do	16

killed from 1893 to 1913. Falls of roof are responsible for 38.31 per cent of all the fatalities since 1893; gas and dust explosions combined represent 33.32 per cent. The average production of coal per fatality was 118,865 tons, or there were 8.41 fatalities per million tons mined.

Since 1903 practically 62 per cent of the men employed in the mines of Alabama have been on a 10-hour basis. This alone partly accounts for the higher rate when compared with Iowa or Ohio, in which States all of the men are on an 8-hour day. The average number of hours worked a year per man is 2,255, as compared with 1,495 for Ohio or 1,704 for Iowa (Table 40). The fatality rate reduced to a 2,000-hour basis becomes 5.78 for the 10-year period 1903–1913, as compared with 6.52 per 1,000 men actually employed.

NUMBER OF HOURS TO THE WORKING DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN ALABAMA.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, or 10 hours per day.	Total number of men employed.
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	20	935	34	7,665	61	10,746	2,092	21,438
1904	17	876	50	5,763	50	8,409	2,763	17,811
1905	24	1,069	32	3,570	65	11,279	3,677	19,595
1906	27	1,096	37	7,808	91	11,258	393	20,555
1907	31	1,994	34	2,339	84	13,942	3,113	21,388
1908	16	1,205	34	2,358	100	11,969	3,665	19,197
1909[b]								17,760
1910	18	766	36	2,633	134	17,306	1,525	22,230
1911	15	550	50	5,345	102	12,628	3,480	22,003
1912	11	338	46	4,145	107	13,938	4,192	22,613
1913	13	420	36	2,496	135	18,185	3,451	24,552

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN ALABAMA AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day (all employees.)	Total hours per year.	Number of 2,000-hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	228	202,753	46,227,684	23,114	57	2.47
1904	216	167,832	36,251,712	18,126	83	4.58
1905	225	186,565	41,977,125	20,989	187	8.91
1906	237	195,157	46,252,209	23,126	96	4.15
1907	242	204,440	49,474,480	24,737	154	6.23
1908	222	183,537	40,745,214	20,373	108	5.30
1909						
1910	249	216,610	53,935,890	26,968	238	8.82
1911	237	210,105	47,693,835	23,847	209	8.77
1912	245	217,117	53,193,665	26,597	123	4.62
1913	255	238,733	60,876,915	30,439	124	4.07

Tables have been compiled showing the fatality rates for all the States both on the basis of actual employees and the number of 2,000-hour workers, so that by referring to Tables 40 and 41 a true comparison of Alabama with other States may be readily made. The tables of statistics for the State follow:

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN ALABAMA.[a]

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899	1,135	68,925	61	1907	80	3,600	45
1900	1,056	50,620	48	1908	8,397	373,513	44
1901	1,170	14,071	1[illegible]	1909			
1902	6,059	139,783	23	1910	25	1,250	50
1903	7,319	231,112	32	1911	210	1,260	6
1904	9,518	762,032	80	1912	384	12,323	32
1905	667	33,262	50	1913	1,048	27,041	26
1906	549	6,576	12	1914	320	3,940	12

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 85.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN ALABAMA, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.

[Figures for total production and all items below horizontal line in various columns selected from Mineral Resources, U. S. Geol. Survey. Figures in column 4 compiled from State mine inspectors' reports. Figures in columns 5, 6, and 7 and averages in columns 9 and 10 prior to 1900 calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial axe or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1840–1886	10,944,018																				
1887	1,950,000							250													
1888	2,900,000	$1.15	6,900						420												
1889	3,572,983	1.11	6,864					248	521	2.10											
1890	4,090,409	1.03	10,642					217	384	1.77											
1891	4,759,781	1.07	9,302					268	512	1.91											
1892	5,529,312	1.05	10,075					271	549	2.03											
1893	5,136,935	.99	11,294	17	1.51	3.31	302,172	237	455	1.92											
1894	4,397,178	.93	10,359	21	1.93	4.78	209,389	238	405	1.70											
1895	5,693,775	.90	10,346	39	3.77	6.85	145,994	244	550	2.25											
1896	5,748,697	.90	9,894	25	2.53	4.35	229,948	248	581	2.34											
1897	5,893,770	.88	10,597	39	3.68	6.62	151,122	233	556	2.39		5.0								45	
1898	6,535,283	.75	10,733	45	4.19	6.89	145,229	250	609	2.44		4.6								37	
1899	7,593,416	1.09	13,481	40	2.97	5.27	189,835	238	563	2.37		3.4			41	10	2			53	
1900	8,394,275	1.17	13,967	37	2.65	4.41	226,872	257	601	2.34		4.4								54	
1901	9,099,052	1.10	17,370	40	2.30	4.40	227,476	236	524	2.22		3.2								82	
1902	10,354,570	1.20	16,439	50	3.04	4.83	207,091	256	630	2.46		2.9								66	
1903	11,654,324	1.22	21,438	57	2.66	4.89	204,462	228	544	2.39		5.0			89	9				98	
1904	11,262,046	1.20	17,811	83	4.66	7.37	135,687	216	632	2.93		6.6			119	22				141	
1905	11,866,069	1.21	19,595	187	9.54	15.76	63,455	225	606	2.69		13.4			171	42				213	
1906	13,107,963	1.34	20,555	96	4.67	7.32	136,541	237	638	2.69		12.5			177	61				238	
1907	14,250,454	1.29	21,388	154	7.20	10.81	92,535	242	666	2.75		12.4			152	42	3			197	
1908	11,604,593	1.26	19,197	108	5.63	9.31	107,450	222	605	2.73		15.4			142	51	4			197	
1909	13,703,450	1.19	17,760	129	7.26	9.41	106,228	(a)	772	(a)		15.0			192	74	17			283	198
1910	16,111,462	1.26	22,230	238	10.71	14.77	67,695	249	725	2.91		18.5			215	82	20			317	221
1911	15,021,421	1.27	22,003	209	9.50	13.91	71,873	227	683	3.01	31.1	19.6	44.1	5.2	184	53	13	22		272	211

1912	16,100,600	1.29	22,613	123	5.44	7.04	130,899	245	712	2.91	41.4	23.2	35.1	.3	222	60	12	59	.....	353	217
1913	17,678,522	1.31	24,552	124	5.05	7.01	142,569	255	720	2.82	35.7	23.3	32.9	1.1	249	42	20	66	.....	377	224
Total	254,954,358	.....	.....	1,561	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (1893–1913)	10,533,707	.....	16,993	83.63	5.25	8.41	118,865	239	635	2.62	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	15,593,422	1.34	24,042	128	5.32	8.21	121,824	226	649	2.87	32.9	31.7	35.3	.1	223	31	20	88	.....	362	207

[a] Not reported.

TABLE 86.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN ALABAMA, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE, DURING THE CALENDAR YEARS 1893 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
[a]	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1893	13	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	1	2	17
1894	11	1	2	.....	.....	2	.....	.....	.....	.....	4	.....	20	.....	1	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	21
1895	19	4	6	3	.....	2	2	.....	.....	.....	.....	.....	36	1	.....	.....	.....	1	.....	.....	1	.....	.....	1	2	39
1896	16	2	3	.....	.....	2	.....	.....	.....	.....	.....	2	25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	25
1897	17	2	4	4	.....	3	.....	.....	.....	.....	5	3	33	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	34
1898	22	2	9	10	.....	.....	.....	.....	.....	.....	.....	1	44	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	45
1899	18	3	5	5	.....	4	1	.....	.....	.....	.....	.....	36	1	.....	1	.....	2	.....	.....	.....	.....	.....	2	2	40
1900	17	2	4	2	.....	3	.....	.....	.....	.....	.....	9	37	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	37
1901	18	6	6	2	.....	6	.....	.....	.....	.....	.....	.....	32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	2	34
1902	29	.....	9	.....	.....	10	.....	.....	.....	.....	.....	.....	48	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	2	50
1903	20	2	6	18	.....	3	.....	.....	.....	.....	.....	8	57	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	57
1904	34	4	7	26	.....	3	.....	.....	.....	.....	.....	9	83	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	83
1905	31	3	8	19	112	4	.....	1	.....	.....	.....	9	187	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	187
1906	45	5	12	13	.....	7	.....	6	.....	.....	.....	2	90	.....	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	6	96
1907	21	3	11	5	57	3	.....	2	.....	.....	.....	52	154	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	154
1908	36	3	16	9	.....	12	.....	10	.....	.....	.....	22	108	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	108
1909	61	9	17	6	18	10	2	4	.....	.....	.....	1	128	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	129
1910	51	4	20	.....	139	10	.....	6	.....	.....	.....	7	237	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	238
1911	43	4	14	2	128	5	.....	6	.....	.....	.....	2	204	1	.....	.....	.....	1	.....	.....	.....	.....	2	2	4	209
1912	56	6	15	26	.....	5	.....	8	.....	.....	.....	1	117	2	1	.....	.....	3	.....	.....	.....	.....	3	.....	3	123
1913	61	7	19	3	[a] 13	2	[a] 11	5	.....	.....	.....	2	123	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	124
1914	53	.....	24	37	.....	1	.....	11	.....	1	.....	.....	127	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1	128

[a] Explosion at Acton No. 2 mine, killed 24.

ARKANSAS.

AREA AND DISTRIBUTION OF COAL FIELDS.

The semibituminous coal field of Arkansas occupies the west-central part of the State, having a length from east to west of 75 miles. At the Oklahoma-Arkansas line it is about 50 miles wide and at the eastern extremity about 25 miles wide. It comprises about 1,580 square miles, of which 75 per cent is considered as productive. The coal-bearing rocks occupy the larger part of Crawford, Franklin, Sebastian, Johnson, and Logan counties.

The lignite field of Arkansas occupies the eastern part of the State and is possibly coextensive with the Tertiary rocks of the Mississippi Valley. The estimated area of these rocks is 6,000 square miles, but workable lignite has been discovered at only a few places, and at no place is it mined on a commercial scale.

SEMIBITUMINOUS FIELD.

The semibituminous field is the eastward extension of the Oklahoma fields, but in Arkansas there is only one coal bed of commercial importance, the Hartshorne, which lies just above the massive Hartshorne sandstone and at the base of the Spadra shale. This coal is mined extensively in the vicinity of Huntington, Midland, Greenwood, and Jenny Lind, in the western part of the field, and is from 3 feet to 8 feet thick. Where the bed is less than 4 feet thick, it is generally clean coal, but where the thickness increases to 6 or 8 feet the bed is broken by many soft shale partings.

The field as a whole is a broad, open synclinal basin or trough, with many minor folds and faults that break the regularity of outline and seriously interfere with economical mining. The Hartshorne coal bed outcrops around the rim of the basin, but only part of the exposed outcrop is thick enough to mine under present conditions.

The coal is of high rank, comparing favorably with the Pocahontas and New River coals of the Appalachian region. In the west end of the field it is semibituminous, but its rank increases eastward to semianthracite about Spadra and Russellville.

MINING METHODS.

The first records of coal production in Arkansas extend back to 1840, when 220 tons of coal were mined. The production has gradually increased to 1913, when 2,234,107 tons were produced. Most of the mines are opened by shafts, but a few are opened by slopes. The room-and-pillar method of mining prevails throughout the State. About 99 per cent of the coal produced comes from the Huntington field, from what is known as the Hartshorne seam of Oklahoma.

Coal-mining machines were used in Arkansas in 1896, at which time there were 14 machines in operation, producing about 3 per cent of the coal. Fifteen to 20 machines were kept in operation until the close of 1902, and from that year until 1910 no mining machines were used in the State. In 1911 there were 14 machines in use, producing a little more than 1 per cent of the coal mined. In 1913 there were 27 machines, producing slightly over 11 per cent of the coal. In 1912, 92 per cent of the coal was shot off the solid; in 1914, 78 per cent was thus mined.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

By an act approved March 7, 1889, the legislature of Arkansas established a Bureau of Mines, Manufactures, and Agriculture, under the supervision of a commissioner, whose duties included the collection and publication of statistics setting forth the extent of the mineral resources of the State, the purpose being to encourage immigration to Arkansas. The act made no provision for the investigation or reporting of mine accidents, but a subsequent law, approved April 4, 1893, which was still in force in 1914, provided for the appointment by the governor of a mine inspector, to whom all fatal or serious accidents in coal mines should be reported by mine operators. The inspector investigates all fatal accidents to determine the cause thereof. He is required to personally inspect all coal mines in the State where 20 or more men are employed underground, to insure the safety and health of the workmen, and to see that the provisions of the act are properly observed and enforced. The act is not applicable to mines employing less than 20 men. Annual reports are rendered to the governor on the 1st day of November of each year.

Mine operators report to the inspector all injuries resulting in at least two days' disability, and these are included in the annual reports which the inspector renders to the governor. Injuries involving 10 or more days' disability are classified as serious, all others being considered slight injuries.

In 1915 the inspector employed no assistants.

ACCIDENTS.

The accompanying tables (Nos. 87 and 88) give the production, number of employees, and number of men killed in and about the coal mines of Arkansas, compiled from the best records available. The accident records began with 1897, although the inspection service began at an earlier date. There are no records for the years 1899, 1900, and 1904, and the record for 1903 is incomplete. For the 9-year period for which continuous records are available, 1905 to 1913, inclusive, 107 men were killed, representing a fatality rate

FATALITIES IN ARKANSAS COAL MINES, BY PRINCIPAL CAUSES, DURING 9 YEARS, 1905 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	65	60.75	1.46
Mine cars and locomotives	2	1.87	.05
Gas and dust explosions	2	1.87	.05
Explosives	15	14.01	.34
Miscellaneous	20	18.69	.45
Shaft	2	1.87	.05
Surface	1	.94	.02
Total, 9 years	107	100.00	2.42

COAL-MINE ACCIDENTS IN ARKANSAS IN WHICH 5 OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Nature of accident.	Number of men killed.
1897 Mar. 4	Kansas and Texas No. 44.	Huntington	Powder and dust explosion.	14
1903 Nov. 20	Bonanza No. 20	Bonanza	Gas explosion	11

of 2.42 per 1,000 men employed. The production per fatality was 180,117 tons, or there were 5.55 fatalities per million tons mined. There have been two serious mine explosions since 1897, in which 25 men were killed.

The 8-hour day prevails in Arkansas and the actual number of hours worked per man a year is 1,314 (Table 40), as compared with 2,255 hours for Alabama and 1,539 hours for Missouri. A fatality rate for the 10-year period, 1903 to 1913 (except 1909), for which

NUMBER OF HOURS TO THE WORKING DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN ARKANSAS.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Number of men employed other than 8, 9, or 10 hours per day.	Total number of men employed.
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	38	4,029	.....	.....	2	14	114	4,157
1904	42	4,472	.....	.....	.....	.....	108	4,580
1905	45	4,146	1	16	.....	.....	30	4,192
1906	55	4,282	.....	.....	.....	.....	16	4,298
1907	67	4,970	.....	.....	.....	.....	115	5,085
1908	67	5,325	.....	.....	.....	.....	12	5,337
1909[b]	.....	.....	.....	.....	.....	.....	.....	5,206
1910	63	5,312	.....	.....	.....	.....	256	5,568
1911	53	5,196	.....	.....	.....	.....	142	5,338
1912	46	4,196	.....	.....	.....	.....	340	4,536
1913	53	4,852	.....	.....	.....	.....	.....	4,652

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN ARKANSAS AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day (all employees).	Total hours per year.	Number of 2,000-hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	223	33,398	7,447,754	3,724	.....	.....
1904	165	36,748	6,063,420	3,032	.....	.....
1905	177	33,582	5,944,014	2,972	8	2.69
1906	165	34,400	5,676,000	2,838	13	4.58
1907	190	40,795	7,751,050	3,876	13	3.35
1908	145	42,708	6,192,660	3,096	14	4.52
1909	.....	.....	.....	.....	.....	.....
1910	128	44,800	5,734,400	2,867	14	4.88
1911	133	42,846	5,698,518	2,849	12	4.21
1912	157	36,628	5,750,596	2,875	6	2.09
1913	174	37,216	6,475,584	3,238	12	3.71

complete data are available, is 2.36 per 1,000 men employed. This, however, reduced to a common basis of 2,000-hour workers, shows a rate of 3.74 per 1,000. Table 41 shows the other States worked out on a similar basis, so that comparisons may be readily made. The tables of statistics for the State follow:

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN ARKANSAS.[a]

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899	2,041	216,265	106	1907	1,185	35,835	30
1900	47	5,040	107	1908	4,037	387,841	96
1901	.....	.....	.....	1909	1,443	41,836	29
1902	14	140	10	1910	4,873	713,210	146
1903	398	2,078	5	1911	665	4,615	7
1904	76	1,424	19	1912	403	37,685	94
1905	625	7,806	12	1913	1,221	32,481	27
1906	3,828	291,095	76	1914	1,415	159,854	113

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 87.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN ARKANSAS, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.

[Figures for total production and all items below horizontal lines in various columns selected from Mineral Resources, U. S. Geol. Survey. Figures in column 4 compiled from State mine inspectors' reports, except for years 1905 to 1909, inclusive, which are from Coal Mining in Arkansas, by A. H. Purdue, in Geological Survey of Arkansas, Part I, 1910. Figures in columns 5, 6, and 7, and averages in columns 9 and 10 prior to 1900, calculated. Figures in italics represent incomplete fatality records.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial axe or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1840–1887	539,798																				
1888	276,871	$1.50	650						426												
1889	279,584	1.42	677					156	413	2.65											
1890	399,888	1.29	938					214	426	1.99											
1891	542,379	1.19	1,317					214	412	1.93											
1892	535,558	1.24	1,128					199	475	2.39											
1893	574,763	1.34	1,559					151	369	2.44											
1894	512,626	1.22	1,493					134	343	2.56											
1895	598,322	1.25	1,218					176	491	2.79											
1896	675,374	1.12	1,507					168	448	2.67		3.1								14	
1897	856,190	1.06	1,990	*17*				161	430	2.67		10.2								15	
1898	1,205,479	1.03	2,555	5	1.96	4.15	241,096	163	472	2.90		12.6								21	
1899	843,554	1.17	2,313	(a)				156	365	2.34		17.4				16				16	
1900	1,447,945	1.14	2,800	(a)				219	517	2.36		14.8								20	
1901	1,816,130	1.14	3,144	18	5.73	9.91	100,896	221	578	2.62		5.6								20	
1902	1,943,932	1.31	3,595	*13*	3.62	6.69	149,533	188	541	2.88		.5								7	
1903	2,229,172	1.51	4,157	*11*				223	536	2.40											
1904	2,009,451	1.54	4,580	(a)				165	439	2.66											
1905	1,934,673	1.49	4,192	8	1.91	4.14	241,834	177	462	2.61											
1906	1,864,268	1.61	4,298	13	3.02	6.97	143,405	165	434	2.63											
1907	2,670,438	1.68	5,085	13	2.56	4.87	205,418	190	525	2.76											
1908	2,078,357	1.68	5,337	14	2.62	6.74	148,454	145	389	2.68											
1909	2,377,157	1.48	5,266	15	2.85	6.31	158,477	(b)	451	(b)											66

1910	1,905,968	1.55	5,568	14	2.51	7.35	136,140	128	342	2.67	.....	.7	.....	6	6	.....	.....	.....	12	63
1911	2,106,789	1.61	5,338	12	2.26	5.70	175,566	133	395	2.97	6.2	1.3	90.4	2.1	.....	10	.....	2	14	89
1912	2,100,819	1.71	4,636	6	1.39	2.86	350,137	167	463	2.95	3.5	3.7	92.2	.6	.....	.....	6	3	9	85
1913	2,294,107	1.76	4,652	12	2.58	5.37	186,176	174	480	2.76	9.2	11.2	79.5	.1	.....	28	4	.....	27	53
Total	36,559,588	.....	.....	171	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (1905–1913)	2,141,200	.....	4,919	11.89	2.49	5.55	180,117	157	435	2.77	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	1,836,540	1.72	4,339	11	2.54	5.99	166,958	145	423	2.96	2.9	19.1	77.9	.1	.....	.....	28	.....	28	56

a Reports either not published or not available.

b Not reported.

TABLE 88.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN ARKANSAS, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE DURING THE CALENDAR YEARS 1897 TO 1914, INCLUSIVE.[a]

Year.	Killed underground.													Killed in shaft.					Killed on surface.								Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.[b]	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1897	1	1	1	.....	14	.....	.....	.....	.....	.....	.....	.....	17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*17*
1898	3	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	5
1899	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(b)
1900	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(b)
1901	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18	18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18
1902	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*13*
1903	.....	.....	.....	11	.....	.....	.....	.....	.....	.....	.....	.....	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*11*
1904	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(b)
1905	5	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	2	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8
1906	6	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	3	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13
1907	7	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	4	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13
1908	8	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	5	14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14
1909	9	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	4	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15
1910	10	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	.....	14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14
1911	9	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	1	11	.....	.....	.....	1	1	.....	.....	.....	.....	.....	.....	.....	12
1912	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	.....	.....	.....	1	1	.....	.....	.....	.....	.....	.....	.....	6
1913	5	1	1	.....	2	1	.....	.....	.....	.....	1	.....	11	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	12
1914	3	.....	3	2	1	1	.....	.....	.....	.....	.....	.....	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1	11

[a] Figures in italics represent incomplete fatality records.

[b] Reports either not published or not available.

CALIFORNIA.

AREA AND DISTRIBUTION OF COAL FIELDS.

The area and distribution of the coal fields of California are described by Parker[a] as follows:

There are in California a number of small, widely separated coal fields, chief among them the Mount Diablo field of Contra Costa County, the Corral Hollow field of Alameda County, a small area in Amador County, the Priest Valley and Trafton fields of San Benito County, and the Stone Canyon field of Monterey County. The first two, which are on the eastern border of San Francisco Bay, and consequently in the west-central part of the State, produce black lignite or subbituminous coal. The areas in Monterey County are more to the south and in or near a region which has been considerably distorted. The coals are of the same geologic age as those farther north, but they have been altered into true bituminous coals. The alteration in the San Benito County area has not progressed so far as in the case of the Monterey County coals, but they closely approach the bituminous grade. None of them possess coking qualities.

The records of the State Mining Bureau of California show a production of coal in that State as early as 1861. It was at that time one of the 16 coal-producing States, and, relatively, of some importance as a coal producer. During the latter part of that decade and throughout the following decade the coal production of California exceeded 100,000 tons annually and reached a maximum of 236,950 tons in 1880. Since 1881 the production has been irregular, having been influenced chiefly, up to the beginning of the present century, by the imports of Australian and British Columbian coals, the receipts of Australian coals depending principally upon the wheat production and shipments from the Pacific coast. Since 1900, with the great increase in the production and use of petroleum which began in that year, coal production in California has fallen to an insignificant quantity.

ACCIDENTS.

Tables 89 and 90 show the production of coal and the number of men employed since 1889, for which reasonably complete records are available. Records of fatalities, however, date back only to 1909. In 1876 there was one explosion at Nortonville, in which six men were killed, and in 1909 there was another at Chancellor, which also killed

COAL-MINE ACCIDENTS IN CALIFORNIA IN WHICH FIVE OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Nature of accident.	Number of men killed.
1876 July 24	Black Diamond	Nortonville	Mine explosion	6
1909 Jan. 19	Stone Canyon	Chancellor	do	6

six men. As is shown by the table following, the coal-mining industry of California is small, hence little attention has been given to the collection of accident and labor records. With the passage of the compensation laws no doubt more complete records will be available in the future. The tables of statistics for the State follow:

[a] Parker, E. W., The production of coal: Mineral Resources of the United States for 1913, U. S. Geol. Survey, 1914, pp. 819–820.

TABLE 89.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN CALIFORNIA, BY CALENDAR YEARS; ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.[a]

[Figures compiled from Mineral Resources, U. S. Geol. Survey, except figures in column 4, which were reported direct to the Bureau of Mines by the operators. Figures in columns 9 and 10 calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial ax or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1861–1885	2,980,671	.....	.....	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1886	100,000	$3.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1887	50,000	3.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1888	95,000	4.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1889	119,820	2.37	253	.....	.....	.....	.....	.....	474	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1890	110,711	2.56	364	.....	.....	.....	.....	301	304	1.01	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1891	93,301	2.20	256	.....	.....	.....	.....	222	364	1.64	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1892	85,178	2.46	187	.....	.....	.....	.....	204	455	2.23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1893	72,603	2.31	158	.....	.....	.....	.....	208	460	2.21	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1894	67,247	2.31	125	.....	.....	.....	.....	232	538	2.32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1895	75,453	2.33	190	.....	.....	.....	.....	262	397	1.52	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1896	78,544	2.12	177	.....	.....	.....	.....	297	444	1.49	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1897	87,992	2.34	381	.....	.....	.....	.....	150	231	1.54	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1898	145,888	2.43	284	.....	.....	.....	.....	265	514	1.94	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1899	160,915	2.67	363	.....	.....	.....	.....	291	443	1.52	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1900	171,708	3.05	378	.....	.....	.....	.....	309	454	1.47	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1901	151,079	2.60	428	.....	.....	.....	.....	289	353	1.22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1902	84,984	2.99	207	.....	.....	.....	.....	312	411	1.32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1903	104,673	2.82	203	.....	.....	.....	.....	307	516	1.68	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	.....
1904	78,888	4.76	168	.....	.....	.....	.....	282	470	1.67	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1905	77,050	4.97	135	.....	.....	.....	.....	294	571	1.94	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1906	25,290	2.40	41	.....	.....	.....	.....	284	617	2.17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1907	13,950	2.74	32	.....	.....	.....	.....	258	436	1.69	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1908	18,755	2.93	34	.....	.....	.....	.....	220	552	2.51	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1909	45,836	2.07	15	6	.....	.....	.....	(b)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1910	11,164	1.64	14	0	.....	.....	.....	192	797	4.15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
1911	10,747	1.50	45	0	.....	.....	.....	254	239	.94	.....	100.0	.....	.....	.....	....	.....	.....	.....	.....	2

Year.	Killed underground.													Killed in shaft.				Killed on surface.						Grand total.
	1	2	3	4	5	6	7	8	9	10	11	12	Total.	13	14	15	16	Total.	17	18	19	20	21	22	Total.	
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
1910	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1911	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1912	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	3
1913	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	2
1914	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE 90.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN CALIFORNIA, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE, 1910 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	1	2	3	4	5	6	7	8	9	10	11	12	Total.	13	14	15	16	Total.	17	18	19	20	21	22	Total.	
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
1912	10,978	2.15	52	.....	2	.....	.....	.....	.....	.....	.....	.....	184	211	1.15	70.9	1.8	22.8	4.5	.....	.....	.....	.....	1	1	4
1913	24,839	3.38	35	.....	.....	.....	.....	.....	.....	.....	.....	.....	332	710	2.14	.....	4.8	95.2	.....	.....	.....	.....	.....	2	2	2
Total	5,153,264	.....	16	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	11,692	2.93	36	.....	.....	.....	.....	.....	.....	.....	.....	.....	279	325	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....

a Figures in italics represent incomplete fatality records.

b Not reported.

COLORADO.

AREA AND DISTRIBUTION OF COAL FIELDS.

The coal fields of Colorado comprise an area of about 19,700 square miles, but in 3,800 square miles of this territory the coal beds may be 3,000 feet or more below the surface.

The fields may be grouped geographically into three groups, known as the Eastern, Park, and Western groups. The fields of each group occupy more or less irregular synclinal basins along the foothills, and on the sides nearer the mountains the rocks are more or less upturned and disturbed.

The Eastern group includes the Trinidad, Canon City, and Boulder coal fields, which yield about two-thirds of the coal now mined in Colorado. The Park group includes the fields in the South, Middle, and North Parks in the north-central part of the State, and is not extensively developed.

The Western group is the largest in area. It includes the Yampa field in the northern part of the State, and, to the south of the Yampa, the Danforth Hills, White River, Grand Hogback, Glenwood Springs, Crested Butte, Grand Mesa, Book Cliffs, and Durango fields, the Durango being in the extreme southwestern part of the State. About one-third of Colorado's coal is produced in this group of fields.

CHARACTER OF COAL BEDS.

In the Trinidad field the coal beds are the same as those of the Raton field in New Mexico and range from 3½ to 9 feet in thickness. In some sections as many as 7 workable beds have been discovered, all of which are contained in the lower 900-foot level of the Vermejo (formerly called Laramie) formation. In the southern part of the field the measures lie nearly horizontal, but to the north the inclination increases slightly, varying from 3° to 10°. The Trinidad field contains a large amount of coking coal and manufactures about 600,000 tons of coke annually. In some mines in the vicinity of Starkville a thick sandstone forms a good roof; in other mines there is a "draw slate" between the coal and sandstone, making a poor roof. In the vicinity of Gray Creek the coal bed is almost level and is rather irregular, ranging from 4 to 14 feet thick.

The second field, as regards production, is the Boulder field, north of Denver. There the coal is much softer than that of the Trinidad field, being classed as subbituminous (black lignite). The associated rocks are also softer, rendering mining more difficult than it is where the rocks are harder and form a better roof. The coal beds range in thickness from 3 to 14 feet and generally are flat-lying, except near the west edge of the basin, where the coal and also the adjacent sandstone and shale beds dip strongly to the east.

In the Canon City field the rocks throughout most of the field dip west about 2° to 5°. Along the western margin of the strata is a thrust fault cutting across the coal measures, and near this fault the beds are sharply upturned, in some instances being practically vertical. The coal beds range in thickness from 2½ to 6 feet and generally are free from partings.

MINING METHODS.

The production of coal in Colorado dates back to 1864, when about 500 tons was mined. The production for 1913 was 9,232,510 tons. The total production for the State up to the end of 1913 is 175,361,698 tons. In 1911, of 140 of the principal mines 41 were shaft and 99 were slope and drift mines. In Las Animas County, which is the largest producer, over 40 mines are slope mines; only one or two are shaft mines. The room-and-pillar system of mining prevails largely throughout the State.

In the Canon City district, the long-wall system has been used to some extent in coal beds that vary from 3 to 4 feet thick and are tapped by shafts 300 to 400 feet deep. At the Radiant mine, where the coal bed is 3 feet to 3 feet 9 inches thick, a combination of the room-and-pillar and the long-wall methods is used, and the coal is undercut by electric machines. The coal is jointed and breaks into large lumps. At the Diamond mine, in the vicinity of Canon City, the coal beds dip 55° to 75°. At the Royal Gorge mine the dip is about 50° and the two coal beds mined are separated 5 feet to 7 feet. The lower bed is mined first by upward stoping from a horizontal level. The Littell mine is opened by a shaft 1,065 feet deep (1908), which is the deepest coal shaft in the State. The coal at this point dips about 5° to the west and is 5½ feet thick.

Coal-mining machines have been in use in Colorado since about 1891, at which time 20 machines were in operation. This number has gradually increased until in 1914 there were 306 machines in use, producing 25 per cent of the coal.

Shooting off the solid is practiced less in Colorado than in many other States, the coal thus mined in Colorado being 11 to 14 per cent of the total coal produced. About 60 per cent of the coal is produced by hand mining methods. The amount of coal mined per man per year in 1887 was 333 tons; in 1913 it was 770 tons.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

The Legislature of Colorado, by an act approved February 24, 1883, provided for the appointment of an examining board, to examine applicants for the position of State inspector of mines. From the

list of eligibles thus established the governor was authorized to appoint a mine inspector for a term of four years. Section 12 provided that the act should apply to any coal mine where more than 12 men were employed underground. The inspector was required to examine at least once each quarter every mine employing more than 20 men, to make a record of such inspection, showing the number of employees, and number of accidents and deaths, and to file a report in the office of the secretary of state on the first Monday in November preceding the biennial sessions of the legislature. This report was included in the biennial report of the secretary of state.

All accidents causing loss of life or serious personal injury were reported by the operators to the inspector. An act of April 8, 1885, extended the inspection law to cover all mines employing more than 10 men, and required the inspector to examine such mines quarterly. On April 2, 1887, a law was approved directing the inspector to render a biennial report to the governor showing the number of persons employed and the number of accidents and deaths from injuries in and about the mines; the inspector was also authorized to employ clerical or other assistance not to exceed $1,500 per year.

An act approved April 4, 1913, authorized the governor to appoint a chief mine inspector and the chief thus selected to appoint five deputy inspectors. The chief and deputy inspectors are selected from a list of eligibles established by a board of examiners. The chief mine inspector divided the State into five districts and assigned one deputy inspector to each district. An annual report for the year ending December 31 is rendered to the governor, the report to enumerate all deaths and accidents causing disability for 5 days or more. Operators are required to render monthly reports of fatal and nonfatal accidents to the inspector, in addition to sending to the chief inspector immediate notice of all fatal accidents.

Accidents resulting in 5 or more days' disability, which under the law are reported to the inspector by mine operators, are published in the inspector's annual reports and are classified as serious or slight according to the judgment of the State mine inspector.

In 1915 the inspector was assisted by four deputies.

ACCIDENTS.

Tables 91 and 92 show the total number of fatalities by causes and calendar years since 1883 as compiled from State mine inspectors' reports. The accompanying tables show the percentage of accidents, classified by principal causes, and fatality rate per 1,000 men employed, over a period of 28 years, 1886–1913, for which continuous records are available. The fatality rate during this period is 7.14 per 1,000 men

FATALITIES IN COLORADO COAL MINES BY PRINCIPAL CAUSES DURING 1886 TO 1913, INCLUSIVE.

Causes.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	852	49.02	3.50
Mine cars and locomotives	141	8.11	.58
Gas and dust explosions	517	29.75	2.12
Explosives	60	3.45	.25
Miscellaneous	83	4.78	.34
Shaft	36	2.07	.15
Surface	49	2.82	.20
Total (28 years)	1,738	100.00	7.14

COAL-MINE ACCIDENTS IN COLORADO IN WHICH 5 OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Nature of accident.	Number killed.
1884 Jan. 24	Crested Butte	Crested Butte	Mine explosion	59
1889 Sept. 9	White Ash	Jefferson County	Inrush of water from old shaft.	10
1893 Jan. 10	Como	King	Mine explosion	24
1896 Feb. 18	Vulcan	New Castle	do	49
1897 Sept. 3	Sunshine	Sunshine	do	12
1901 Sept. 16	Spring Gulch	Spring Gulch	do	6
1902 Aug. 7	Bowen	Bowen	Powder and mine explosion.	13
1904 Oct. 28	Tercio	Tercio	Mine explosion	19
1906 Feb. 19	Maitland	Walsenburg	do	14
1906 Apr. 22	Cuatro	Tercio	do	19
1907 Jan. 23	Primero	Primero	do	24
1907 May 19	Engleville	Engleville	Mine fire	5
1909 July 6	Toller	Tollerville	Mine explosion	9
1910 Jan. 31	Primero	Primero	do	75
1910 Oct. 8	Starkville	Starkville	do	56
1910 Nov. 8	Victor American No. 3.	Delagua	Mine fire and explosion.	79
1910 Dec. 14	Leyden	Leyden	Mine fire	10
1911 Feb. 9	Cokedale	Trinidad	Mine explosion	17
1912 June 18	Hastings	Hastings	do	12
1913 Dec. 16	Vulcan	New Castle	do	37

employed. There were 19 accidents in which 5 or more men were killed at one time, representing slightly over 28 per cent of all of the fatalities due to mine accidents. Of the total number of fatalities 49.02 per cent were due to falls of roof and pillar and 29.75 per cent to gas and dust explosions. The average production of coal per fatality during this period was 96,798 tons, or there were 10.33 fatalities for each million tons mined.

Beginning with 1903 and including 1912 about 50 per cent of the men were on a 10-hour basis. In 1913 the 8-hour law became effective and only a few men were employed for a longer day than eight hours. The time element has been taken into consideration and tables compiled on this basis for comparison with other States. The fatality rate for the 10-year period, 1903–1913 (Table 40), based on the actual

NUMBER OF HOURS TO THE WORKING-DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN COLORADO.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Number of men employed other than 8, 9, or 10 hours per day.	Total number of men employed.
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	24	488	17	692	70	7,743	306	9,229
1904	55	2,058	11	432	57	5,583	50	8,123
1905	61	3,660	4	189	40	6,551	620	11,020
1906	67	5,259	9	655	48	5,222	232	11,368
1907	60	3,420	8	312	54	7,439	3,052	14,223
1908	79	5,158	3	63	61	8,535	767	14,523
1909[b]								11,472
1910	61	2,935	8	303	49	5,913	6,713	15,864
1911	57	2,701	10	299	46	4,559	6,814	14,373
1912	61	2,923	5	173	50	4,631	5,273	13,000
1913	146	11,175	3	75	5	128	642	11,980

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN COLORADO, AND THE FATALITY RATE, BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day (all employees).	Total hours per year.	Number of 2,000-hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	245	90,316	22,127,420	11,064	44	3.98
1904	261	76,632	20,000,952	10,000	94	9.40
1905	255	102,071	26,028,105	13,014	65	4.99
1906	268	102,275	27,409,700	13,705	89	6.49
1907	258	132,026	34,032,708	17,031	107	6.28
1908	212	134,084	28,425,808	14,213	63	4.43
1909						
1910	236	145,754	34,397,944	17,199	323	18.78
1911	207	131,215	27,161,505	13,581	88	6.48
1912	227	118,708	26,946,716	13,473	96	7.13
1913	229	96,863	22,181,627	11,091	108	9.74

number of employees is 8.71, whereas on the number of 2,000-hour workers it is 8.02 per 1,000. During the 10-year period the men averaged 2,172 hours employment per year. Table 41 shows the fatality rate for each year on the 2,000-hour basis, 1903–1913, for each State, so that a true comparison of Colorado with other States may be readily made.

The tables of statistics for the State follow.

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN COLORADO.[a]

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899	504	31,520	62	1907	215	6,378	30
1900	17	935	55	1908	768	16,646	22
1901	1,527	86,045	56	1909	55	1,250	23
1902	444	20,845	47	1910	2,044	195,558	96
1903	7,103	407,909	57	1911	150	32,375	216
1904	3,865	481,482	125	1912	.....	.....	.....
1905	.....	.....	.....	1913	7,324	552,082	75
1906	.....	.....	.....	1914	4,418	1,090,025	247

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 91.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN COLORADO, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.

[Figures for total production and all items below horizontal line in various columns selected from Mineral Resources, U. S. Geol. Survey. All items in column 4 and others above horizontal lines in columns 3, 8, 20, and 21 from State mine inspectors' reports. Figures in columns 5, 6, and 7, and averages in columns 9 and 10 for years prior to 1900 calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man—		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial ax or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1864–1882	3,410,445																				
1883	1,229,593			6																	
1884	1,130,024			64		56.64	17,657														35
1885	1,356,062	$2.25		9		6.64	150,674	(a)													
1886	1,368,338	2.35	3,500	6	1.71	4.38	228,056	(a)	391												
1887	1,791,735	2.20	5,375	12	2.23	6.70	149,311	(a)	333												
1888	2,185,477	2.20	5,575	29	5.20	13.27	75,361	(a)	392												
1889	2,597,181	1.54	4,904	24	4.89	9.24	108,216	(a)	530												
1890	3,077,033	1.40	5,827	16	2.75	5.20	192,313	220	528	2.40											
1891	3,512,632	1.37	6,000	30	5.00	8.54	117,088	(a)	585											20	
1892	3,510,830	1.62	5,747	33	5.74	9.40	106,389	229	611	2.67											
1893	4,102,389	1.24	7,202	46	6.39	11.21	89,182	188	570	3.03											
1894	2,831,409	1.24	6,507	19	2.92	6.71	149,022	155	435	2.81											
1895	3,082,982	1.20	6,125	23	3.76	7.46	134,043	182	503	2.76											
1896	3,112,400	1.16	6,704	68	10.14	21.85	45,771	172	464	2.70		10.2								34	
1897	3,361,703	1.17	5,852	36	6.15	10.71	93,381	180	574	3.19		10.5								37	106
1898	4,076,347	1.15	6,440	23	3.57	5.64	177,233	220	633	2.88		5.5								43	107
1899	4,776,224	1.12	7,166	40	5.58	8.37	119,406	246	667	2.71		11.0			37	26				63	110
1900	5,244,364	1.12	7,459	31	4.16	5.91	169,173	264	703	2.66		14.4								90	120
1901	5,700,015	1.13	8,870	55	6.20	9.65	103,637	253	643	2.54		5.6								62	98
1902	7,401,343	1.13	8,956	73	8.15	9.86	101,388	261	826	3.16		11.6								98	125
1903	7,423,602	1.23	9,229	44	4.77	5.93	168,718	245	804	3.28		17.1			88	65	4			157	
1904	6,658,355	1.31	8,123	94	11.57	14.12	70,834	261	820	3.14		14.2			67	56	2			125	
1905	8,826,429	1.22	11,020	65	5.90	7.36	135,791	255	801	3.14		14.1			74	42	5			121	175
1906	10,111,218	1.26	11,368	89	7.83	8.80	113,609	268	889	3.32		13.2			80	51	10			141	180

1907	10,700,226	1.40	14,223	107	7.53	9.92	100,843	238	759	2.94	.....	15.7	.....	.....	108	58	14	.....	.....	175	.....
1908	9,634,973	1.41	14,523	68	4.34	6.54	152,936	212	663	3.13	.....	17.3	.....	.....	137	56	18	.....	.....	211	.....
1909	10,716,936	1.33	11,472	97	8.46	9.05	110,484	(a)	934	(a)	.....	18.0	.....	.....	175	66	12	.....	.....	253	143
1910	11,973,736	1.42	15,864	323	20.36	26.98	37,070	236	755	3.20	.....	16.0	.....	.....	193	55	19	.....	.....	286	191
1911	10,157,383	1.45	14,373	88	6.12	8.66	115,426	207	707	3.42	67.3	19.5	12.4	10.8	157	26	24	17	8	242	169
1912	10,977,824	1.49	13,000	96	7.38	8.74	114,352	227	844	3.72	64.5	23.2	11.9	.4	187	33	16	57	11	304	159
1913	9,232,510	1.52	11,990	108	9.01	11.70	85,486	229	770	3.36	60.6	26.0	13.9	.5	168	35	12	80	5	300	171
Total	175,361,008	.....	.....	1,817	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (1886–1913)	6,008,413	.....	8,693	62.67	7.14	10.33	98,796	220	691	3.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	8,170,559	1.66	10,068	75	7.43	9.18	108,941	244	809	3.32	67.3	30.6	11.6	.6	168	35	11	87	5	306	163

a Not reported.

TABLE 92.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN COLORADO, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE DURING THE CALENDAR YEARS 1883 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1883 [a]	4	.....	1	1	.....	.....	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
1884	1	1	3	59	.....	.....	.....	.....	.....	.....	.....	.....	64	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	64
1885	4	.....	3	1	.....	.....	.....	.....	.....	.....	.....	.....	8	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	9
1886	3	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1	6
1887	9	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	11	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	12
1888	12	3	4	5	3	2	.....	.....	.....	.....	.....	.....	29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	29
1889	5	4	3	.....	.....	.....	.....	.....	.....	.....	.....	11	23	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	24
1890	6	4	1	1	.....	2	.....	.....	.....	.....	.....	.....	14	2	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	16
1891	17	5	2	.....	2	3	.....	.....	.....	.....	.....	1	30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	30
1892	11	10	2	2	1	3	.....	.....	.....	.....	.....	.....	29	1	1	2	.....	4	.....	.....	.....	.....	.....	.....	.....	33
1893	13	3	3	.....	[b] 24	1	.....	.....	.....	.....	.....	.....	44	.....	.....	1	.....	1	.....	.....	.....	1	.....	.....	1	46
1894	11	2	1	1	.....	1	.....	.....	.....	.....	.....	1	17	1	.....	.....	.....	1	1	.....	.....	.....	.....	.....	1	19
1895	6	6	3	4	.....	2	.....	.....	.....	.....	.....	.....	21	.....	.....	.....	2	2	.....	.....	.....	.....	.....	.....	.....	23
1896	14	2	2	.....	49	.....	.....	.....	.....	.....	.....	1	68	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	68
1897	15	4	3	.....	12	1	.....	.....	.....	.....	.....	1	36	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	36
1898	13	3	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	20	.....	.....	1	.....	1	2	.....	.....	.....	.....	.....	2	23
1899	28	3	6	.....	.....	1	.....	.....	.....	.....	.....	.....	38	.....	.....	1	.....	1	1	.....	.....	.....	.....	.....	1	40
1900	19	6	2	.....	.....	1	.....	.....	.....	.....	1	.....	29	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	2	31
1901	25	3	8	2	8	1	.....	1	1	1	.....	2	53	.....	1	.....	.....	1	.....	.....	.....	2	.....	.....	2	55
1902	37	5	2	8	14	3	.....	.....	.....	.....	2	.....	71	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	2	73
1903	26	5	2	.....	1	4	.....	1	.....	.....	.....	1	40	2	.....	.....	.....	2	2	.....	.....	.....	.....	.....	2	44
1904	43	10	10	.....	19	4	.....	1	.....	.....	.....	2	80	1	.....	1	.....	2	1	.....	.....	.....	1	1	3	85
1905	35	6	8	.....	.....	4	.....	4	.....	.....	.....	.....	57	2	.....	1	.....	3	2	.....	.....	.....	.....	3	5	65
1906	37	7	2	34	.....	4	.....	1	.....	.....	.....	.....	85	1	.....	1	.....	2	2	.....	.....	.....	.....	.....	2	89
1907	51	5	9	1	25	2	.....	.....	.....	.....	7	.....	100	2	.....	1	.....	3	1	1	.....	.....	1	1	4	107
1908	33	5	9	5	.....	3	.....	.....	2	.....	.....	2	59	2	.....	.....	.....	2	1	.....	.....	.....	.....	1	1	62
1909	56	7	7	12	3	3	.....	1	.....	.....	.....	.....	82	.....	1	2	.....	3	1	.....	1	.....	1	2	5	87
1910	62	11	18	79	131	5	.....	.....	.....	.....	10	2	318	2	.....	.....	.....	2	1	.....	1	.....	.....	1	3	323

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GEORGIA.

AREA AND DISTRIBUTION OF COAL FIELDS.

Parker [a] describes the coal-productive area of Georgia as follows

The coal-productive area of Georgia underlies portions of two counties in the extreme northwestern corner of the State. The Walden Basin of Tennessee crosses Dade County, in Georgia, and extending southwesterly becomes the Blount Mountain and Warrior Basins in Alabama. The Lookout Basin, a narrow outlying area, extends from Etowah County, in Alabama, in a northeasterly direction into Walker County, Ga. The total area of the coal fields in Georgia is estimated at 167 square miles the smallest coal area of any Appalachian State. Not all of the field is workable. Extensive operations have been carried on in both counties, however, but all of the production in 1913 was by two companies operating in Walker County. On account of its high percentage (80 per cent) of fixed carbon and its low sulphur content, the Lookout Mountain coal (Walker County) gives a large product of excellent coke which is sold to the furnaces of Chattanooga and of other points in Tennessee and in Georgia.

The earliest report by the United States Geological Survey on the production of coal in Georgia is for 1860, when 1,900 tons were mined. The production gradually increased to its highest point in 1903, when 416,951 tons were produced, and since then has gradually declined to approximately 200,000 in recent years. No mining machines are used in the coal mines of Georgia. The reports of the United States Geological Survey show that all of the coal in 1913 [b] was shot off the solid. Of the total production, approximately one-third of the coal is washed.

ACCIDENTS.

Tables 93 and 94 show the total number of fatalities by causes and calendar years since 1909. They also show the percentage of accidents and fatality rate per 1,000 men employed. The average production of coal per fatality during this period was 148,111 tons, or there were 6.75 fatalities per million tons mined.

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[a] Parker, E. W., Production of Coal, Mineral Resources of the United States for 1913, U. S. Geol. Survey, 1914, p. 825.

[b] Parker, E. W., op cit., p. 825.

FATALITIES IN GEORGIA COAL MINES, BY PRINCIPAL CAUSES, DURING THE YEARS 1909 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	6	85.71	2.60
Mine cars and locomotives	.....	.....	.....
Gas and dust explosions	.....	.....	.....
Explosives	1	14.29	.43
Miscellaneous	.....	.....	.....
Shaft	.....	.....	.....
Surface	.....	.....	.....
Total (5 years)	7	100.00	3.03

There is no mine inspection in the State. The tables of statistics for the State follow:

TABLE 93.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN GEORGIA, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.

[Compiled from Mineral Resources, U. S. Geol. Survey, except figures in column 4, which were reported direct to the Bureau of Mines by the operators. Figures in columns 9 and 10 calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed—			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial axe or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1860–1887	2,284,259	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1888	180,000	.....	500	.....	.....	.....	.....	.....	360	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1889	225,934	$1.50	733	.....	.....	.....	.....	.....	308	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1890	228,337	1.04	425	.....	.....	.....	.....	313	537	1.72	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1891	171,000	1.50	850	.....	.....	.....	.....	312	201	.64	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1892	215,498	.99	467	.....	.....	.....	.....	277	461	1.66	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1893	372,740	.98	736	.....	.....	.....	.....	342	506	1.48	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1894	354,111	.85	729	.....	.....	.....	.....	304	486	1.60	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1895	260,998	.83	848	.....	.....	.....	.....	312	308	.99	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1896	238,546	.70	713	.....	.....	.....	.....	303	335	1.11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1897	195,869	.72	469	.....	.....	.....	.....	304	418	1.38	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1898	244,187	.81	534	.....	.....	.....	.....	298	457	1.53	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1899	233,111	1.00	567	.....	.....	.....	.....	302	411	1.36	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1900	315,557	1.17	681	.....	.....	.....	.....	278	463	1.67	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1901	342,825	1.20	791	.....	.....	.....	.....	291	433	1.49	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1902	414,083	1.42	755	.....	.....	.....	.....	312	548	1.76	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1903	416,951	1.25	681	.....	.....	.....	.....	298	612	2.05	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1904	383,191	1.22	881	.....	.....	.....	.....	222	435	1.96	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1905	351,991	1.29	801	.....	.....	.....	.....	270	439	1.63	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1906	332,107	1.28	737	.....	.....	.....	.....	279	451	1.62	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1907	362,401	1.38	808	.....	.....	.....	.....	262	449	1.71	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1908	264,822	1.38	670	.....	.....	.....	.....	261	395	1.51	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1909	211,196	1.41	460	2	4.35	9.47	105,598	(a)	459	(a)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1910	177,245	1.46	386	0	.....	.....	.....	285	459	1.73	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3
1911	165,210	1.49	510	0	.....	.....	.....	277	324	1.17	9.8	.....	.....	90.2	.....	.....	.....	.....	.....	.....	2

1912	227,503	1.49	450	2	4.44	8.79	113,752	254	506	1.99	65.0	.....	35.0	.....	.....	.....	.....	.....	.....	.....	.....	2
1913	255,626	1.41	500	3	6.00	11.74	85,209	261	511	1.96	.....	.....	100.0	.....	.....	.....	.....	.....	.....	.....	.....	2
Total	9,425,298	.....	.....	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (1909–1913)	207,356	.....	461	1.40	3.03	6.75	148,111	265	450	1.70	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	166,498	1.44	355	1	2.82	6.01	166,498	207	469	2.27	.....	.....	100.0	.....	.....	.....	.....	.....	.....	.....	.....	2

[a] Not reported.

TABLE 94.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN GEORGIA,[a] WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE DURING THE CALENDAR YEARS 1909 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and bursting gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1909	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
1910	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1911	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1912	1	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
1913	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3
1914	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1

[a] Figures for 1909 are from Mineral Resources, U. S. Geol. Survey; others from reports of mine operators as received by the Bureau of Mines.

ILLINOIS.

AREA AND DISTRIBUTION OF COAL FIELDS.

The Illinois coal field is the western part of a broad and relatively flat basin which extends eastward into Indiana and southeastward into Kentucky. On the southwestern border of the field the coal beds are turned up perceptibly, and on the south the margin is marked by a much steeper fold, which is overturned and faulted near Shawneetown where it crosses Ohio River. On the north border the coal beds are bent into a low, though sharply defined anticline which extends from La Salle southeastward toward Clark County. Minor folds, local in extent, occur in different parts of the basin, but in general the beds dip gently from the margins of the field to a central deep area where the coal-bearing rocks have a thickness of about 1,500 feet.

CHARACTER OF COAL BEDS.

There are in the Illinois field a number of coal beds of varying thickness, each of which, however, is fairly regular and continuous over large areas. The coal production of Illinois is from six beds, Nos. 1 to 3 and 5 to 7. No. 6 is the most important and averages 6 feet thick. This bed produces over 50 per cent of the coal; No. 5 produces 25 per cent; and No. 2, 10 per cent.

The beds are practically horizontal and have been opened at different depths in the various counties. In Gallatin County two coal beds have been mined at depths of 60 and 180 feet, the upper being 5 feet thick and the lower 3 feet thick. In Macoupin County, near Virden, coal No. 5 is 7 feet 8 inches thick at a depth of 320 feet. In St. Clair County, near Belleville, coal No. 6 is 8 feet 4 inches thick at a depth of 380 feet. In Marion County, at Centralia, coal No. 6 is 7 feet thick at a depth of 569 feet and at Sandoval 6 feet thick at a depth of 603 feet. In Sangamon County the principal coal bed is 6 feet thick with a good limestone roof and is opened by shafts varying from 65 to 225 feet in depth. In Perry County the Belleville, or No. 6, coal bed is 5 to 6 feet thick at depths varying from 30 to 200 feet and dips slightly north. A shaft at Assumption, Christian County, is 1,003 feet deep, being the deepest in the State.

Illinois coal is bituminous, but has a moisture content as it comes from the mine of 7 to 16 per cent. The best coal contains 7 to 10 per cent of ash, one-half to 3 per cent of sulphur, and 40 to 50 per cent of fixed carbon.

MINING METHODS.

The record of coal-production for Illinois begins in 1833, during which year 6,000 tons were mined. The production for the State has gradually increased until in 1913 it amounted to 61,618,744 tons.

As in Indiana, the shaft mines largely predominate over slope and drift mines, which number less than 50. In 1897 only 52 out of 853 mines used the longwall method, and these were in the northeastern part of the State in the No. 2 bed, where the coal is only 3 feet thick. In the other mines the room-and-pillar system of mining prevails with slight alterations for individual mines or different coal beds. In 1897 only one-half of the coal was undercut before blasting, leaving about 50 per cent as shot off the solid. In 1912, 40 per cent of the coal was shot off the solid, but in 1913 this was reduced to 32.3 per cent. In 1888 there were 272 mining machines in the mines, producing 18.9 per cent of the coal, and in 1913 there were 1,845 machines, which produced 53 per cent of the coal, or 17,685 tons per machine. The coal, being horizontal and uniform, is well adapted to machine mining.

Most of the mines are dry, and but little pumping is required. The deeper mines are drier than the shallow ones and require sprinkling to prevent accumulation of dust.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

The inspection of coal mines in Illinois was inaugurated by virtue of an act of the general assembly approved March 27, 1872, which became effective July 1, 1872. By section 11 of this act the county surveyors were constituted ex-officio inspectors of mines within their respective counties, each with authority to call to his aid a reputable practical miner. The act also provided that all accidents causing loss of life or serious personal injury at any coal mine or colliery should be reported to the county mine inspector, and that all fatal accidents should also be reported to the coroner of the county in which the accident occurred. It was made the duty of the inspector to investigate all accidents thus reported to him, and all expenses incident to his investigation were payable by the county in which the accidents occurred.

By an act approved June 18, 1883, effective July 1, 1883, the State was divided into five mining districts, and a State mine inspector for each district authorized. Each county was authorized to appoint an assistant mine inspector, if it so desired, such county inspector to perform his duties under the direction of the district mine inspector. The act directed that accidents should thereafter be reported to the district mine inspector instead of the county inspector, and that fatal accidents might be reported to a justice of the peace in the absence or inability to act of the county coroner.

Subsequent laws have made no change in the reportability of mine accidents as above set forth. There are now 12 inspection districts in the State.

ACCIDENTS.

Tables Nos. 95 and 96 show the total number of fatalities by causes and calendar years since 1885, and the total production of coal. They also show the percentage of accidents, by principal causes, and fatality rate per 1,000 employed over a period of 29 years, for which continuous records are available. During this period there were 3,409

FATALITIES IN ILLINOIS COAL MINES, BY PRINCIPAL CAUSES, DURING THE YEARS 1885 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	1,616	47.40	1.19
Mine cars and locomotives	414	12.14	.30
Gas and dust explosions	170	4.99	.13
Explosives	459	13.47	.34
Miscellaneous	350	10.27	.26
Shaft	266	7.80	.20
Surface	134	3.93	.10
Total, 29 years	3,409	100.00	2.52

COAL-MINE ACCIDENTS IN ILLINOIS IN WHICH 5 OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Nature of accident.	Number killed.
1883 Jan. 9	Coulterville	Coulterville	Mine explosion	10
1883 Feb. 16	Diamond	Braidwood	Inrush of surface water into workings.	69
1903 Mar. 15	Cardiff	Cardiff	Mine explosion	5
1903 Mar. 23	Athens No. 2	Athens	Windy shot	6
1903 Mar. 31	Sandoval	Sandoval	Blown-out shot	8
1904 May 11	Big Muddy	Herrin	Powder explosion	10
1905 Jan. 16	Decatur	Decatur	Mine fire	6
1905 Apr. 3	Lelter	Zeigler	Mine explosion	49
1906 Dec. 22	Breese-Trenton	Breese	Cage with men fell down shaft.	6
1907 Jan. 29	Johnston City	Johnston City	Powder explosion	7
1909 Jan. 10	Zeigler	Zeigler	Mine fire and explosion	26
1909 Nov. 13	St. Paul No. 2	Cherry	Mine fire	259
1909 Dec. 23	Mine A	Herrin	Mine explosion	8
1910 Nov. 11	Shoal Creek No. 1	Panama	do	6
1911 Oct. 23	O'Gara No. 9	Harrisburg	do	8
1913 Feb. 19	Seagraves	Eldorado	do	5
1914 Oct. 27	North or No. 1	Royalton	do	52
1915 Apr. 5	Shoal Creek	Panama	do	11
1915 July 27	United Coal No. 1	Christopher	do	9

fatalities or 2.52 per 1,000 men employed. There were 14 accidents in which 5 or more men were killed at one time, representing about 12 per cent of the total fatalities. These large accidents include the mine fire at Cherry in which 259 men were killed at one time. The average production of coal per fatality during this period was 251,900 tons or 3.97 fatalities per million tons mined.

Practically all of the mines in Illinois are operated on an 8-hour basis so that a comparison with 10-hour States on the basis of days worked is not a proper method. The time element has therefore been taken into consideration and a table compiled on the basis of the actual number of hours worked so that a true comparison with other

NUMBER OF HOURS TO THE WORKING DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN ILLINOIS.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, or 10 hours per day.	Total number of men employed.
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	542	47,773	11	57	9	45	2,721	50,596
1904	547	53,500	17	121	10	52	1,012	54,685
1905	583	56,296	8	64	6	405	1,288	58,053
1906	482	60,081	9	610	1	30	1,267	61,988
1907	457	60,268	8	675	1	4	4,634	65,581
1908	491	65,289	5	510	.....	.....	2,236	68,035
1909[b]	.....	.....	.....	.....	.....	.....	.....	69,425
1910	521	69,575	7	137	1	4	2,929	72,645
1911	513	75,088	9	68	2	10	490	75,656
1912	490	75,411	10	67	.....	.....	2,620	78,098
1913	482	78,137	7	41	1	5	1,346	79,529

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN ILLINOIS AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day. (all employees.)	Total hours per year.	Number of 2,000 hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	228	407,636	92,941,008	46,471	158	3.40
1904	213	438,717	93,446,721	46,723	173	3.70
1905	201	466,586	93,783,786	46,892	203	4.33
1906	192	497,841	95,585,472	47,793	161	3.37
1907	218	529,965	115,532,370	57,766	192	3.32
1908	185	547,026	101,199,810	50,600	172	3.40
1909	.....	.....	.....	.....	.....	.....
1910	160	584,234	93,477,440	46,739	143	3.06
1911	188	605,826	113,895,288	56,948	172	3.02
1912	194	627,471	121,729,374	60,865	163	2.68
1913	189	637,629	120,511,881	60,256	164	2.72

States may be made. The fatality rate for the 10-year period, 1903–1913 (Table 40), for Illinois on the 2,000-hour basis is 3.26 as compared with 2.55 based on the actual number of men employed. During the 10-year period, the men averaged 1,567 hours per year as compared with 2,132 hours in West Virginia.

The tables of statistics for the State of Illinois follow:

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN ILLINOIS.[a]

Year.	Number of men affected.	Total number of days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total number of days lost.	Average number of days lost per man.
1899	7,133	267,171	37	1907	5,255	35,191	7
1900	3,909	134,433	34	1908	47,456	1,737,611	37
1901	3,740	79,245	21	1909	2,335	90,720	38
1902	3,916	65,231	17	1910	67,218	9,133,953	136
1903	3,772	70,731	19	1911	5,543	100,588	18
1904	16,983	156,528	9	1912	60,505	2,026,526	33
1905	15,289	321,967	21	1913	11,861	655,622	55
1906	49,792	2,900,525	58	1914	23,506	970,466	41

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 95.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN ILLINOIS, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES USED.

[Figures for total production and all items below horizontal line in various columns selected from Mineral Resources, U. S. Geol. Survey. All items in column 4 and others above horizontal lines in columns 2, 3, 8, 12, 20, and 21 from State mine inspectors' reports. Figures in columns 5, 6, and 7, and averages in columns 9 and 10 prior to 1900, calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial axe or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1833–1881	73,341,123	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1882	9,115,653	.....	20,290	a 40	1.97	4.39	227,891	245	449	1.83	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1883	12,123,456	.....	23,939	a 134	5.60	11.05	90,474	273	506	1.85	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	438
1884	12,208,075	.....	25,575	a 46	1.80	3.77	265,393	200	477	2.38	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	479
1884[b]	.....	.....	.....	18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1885	11,834,459	$1.17	25,946	50	1.93	4.22	236,689	225	456	2.03	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	492
1886	11,175,241	1.11	25,846	36	1.39	3.22	310,423	206	432	2.10	.....	.....	.....	.....	.....	.....	.....	.....	.....	235	478
1887	12,423,066	1.09	26,804	51	1.90	4.11	243,590	213	463	2.17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	481
1888	14,328,181	1.12	29,410	57	1.94	3.98	251,372	221	487	2.20	.....	18.9	.....	.....	.....	.....	.....	.....	.....	272	495
1889	12,104,272	.97	30,076	41	1.36	3.39	295,226	214	402	1.88	.....	20.2	.....	.....	.....	.....	.....	.....	.....	235	533
1890	15,292,420	.93	28,574	57	1.99[c]	3.73	268,288	204	535	2.62	.....	22.8	.....	.....	.....	.....	.....	.....	.....	266	538
1891	15,660,698	.91	32,951	49	1.49	3.13	319,606	216	475	2.20	.....	18.7	.....	.....	.....	.....	.....	.....	.....	241	515
1892	17,862,276	.91	34,585	69	2.00	3.86	258,874	220	516	2.35	.....	19.9	.....	.....	.....	.....	.....	.....	.....	270	507
1893	19,949,564	.89	35,390	83	2.35	4.16	240,356	229	564	2.46	.....	21.0	.....	.....	.....	.....	.....	.....	.....	388	506
1894	17,113,576	.89	38,477	57	1.48	3.33	300,238	183	445	2.43	.....	18.0	.....	.....	.....	.....	.....	.....	.....	278	524
1895	17,735,864	.80	38,630	78	2.02	4.40	227,383	182	459	2.52	.....	18.4	.....	.....	.....	.....	.....	.....	.....	283	536
1896	19,786,626	.80	39,560	70	1.77	3.54	282,666	186	500	2.69	.....	19.6	.....	.....	.....	.....	.....	.....	.....	307	532
1897	20,072,758	.72	33,788	73	2.16	3.64	274,969	185	594	3.21	.....	19.7	.....	.....	.....	.....	.....	.....	.....	320	507
1898	18,599,299	.78	35,026	90	2.57	4.84	206,659	175	531	3.03	.....	18.4	.....	.....	.....	.....	.....	.....	.....	392	530
1899	24,439,019	.85	36,756	73	1.99	2.99	334,781	228	665	2.92	.....	24.9	.....	.....	363	77	.....	.....	.....	440	543
1900	25,767,981	1.04	39,101	102	2.61	3.96	252,627	226	659	2.92	.....	19.7	.....	.....	.....	.....	.....	.....	.....	430	580
1901	27,331,552	1.03	41,880	107	2.55	3.91	255,435	220	653	2.97	.....	21.1	.....	.....	.....	.....	.....	.....	.....	464	602
1902	32,939,373	1.03	47,411	107	2.26	3.25	307,845	226	695	3.08	.....	21.6	.....	.....	.....	.....	.....	.....	.....	508	601
1903	36,957,104	1.17	50,596	158	3.12	4.28	233,906	228	730	3.20	.....	20.0	.....	.....	451	100	2	.....	.....	553	620
1904	36,475,060	1.10	54,685	173	3.16	4.74	210,838	213	667	3.13	.....	19.5	.....	.....	541	102	.....	.....	.....	643	631

1905	38,434,963	1.06	55,053	208	3.50	5.28	189,332	201	662	3.29	.....	22.6	.....	.....	758	128	1	.....	882	599
1906	41,480,104	1.08	61,828	161	2.60	3.88	257,540	192	669	3.48	.....	27.9	.....	.....	874	171	3	.....	1,048	652
1907	51,317,146	1.07	66,831	192	2.93	3.74	267,277	218	768	3.59	.....	29.5	53.1	.....	836	248	1	.....	1,090	673
1908	47,059,600	1.06	65,085	172	2.63	3.61	277,091	185	701	3.79	.....	31.6	57.2	.....	876	338	3	.....	1,217	674
1909	50,904,990	1.06	69,425	458	6.60	9.00	111,146	(c)	733	(c)	.....	34.0	45.1	.....	845	405	10	.....	1,260	620
1910	45,900,246	1.14	72,645	143	1.97	3.12	230,981	190	682	3.95	.....	38.6	52.5	.....	816	543	2	.....	1,361	662
1911	53,679,118	1.11	75,656	172	2.27	3.20	312,088	193	710	3.78	13.3	43.0	38.1	5.6	790	555	20	47	1,402	579
1912	59,385,226	1.17	78,068	163	2.09	2.73	367,894	194	767	3.95	12.8	44.9	40.3	2.0	847	701	22	81	1,654	582
1913	61,618,744	1.14	79,529	164	2.06	2.66	376,724	190	775	4.10	13.1	53.0	38.2	0.7	802	906	55	82	1,845	526
Total	965,516,328	.....	.....	3,647	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average, 1885–1913	29,611,311	.....	44,707	117.55	2.53	3.97	251,900	208	634	3.14	.....	.....	.....	1.0	646	963	48	129	1,812	492
1914	57,589,197	1.12	79,499	193	2.43	3.35	298,390	173	724	4.18	10.4	56.7	31.9	.....	.....	.....	.....	.....	.....	.....

a Fiscal year ending June 30. b July 1 to Dec. 31. c Not reported.

TABLE 96.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN ILLINOIS, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions.	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1882 a	3	.....	2	.....	.....	5	.....	.....	.....	.....	.....	29	39	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	40
1883 a	40	.....	.....	10	.....	.....	.....	.....	.....	.....	.....	84	134	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	134
1884 a	29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	17	46	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	46
1884 (July 1 to Dec. 31)	5	2	1	.....	.....	1	1	.....	.....	.....	.....	.....	10	3	1	2	1	7	.....	.....	1	.....	.....	.....	1	18
1885	25	6	.....	.....	.....	8	.....	.....	.....	.....	.....	.....	39	2	.....	4	.....	6	.....	.....	2	1	2	.....	5	50
1886	18	7	5	.....	.....	2	.....	.....	.....	.....	.....	.....	32	1	1	2	.....	4	.....	.....	.....	.....	.....	.....	.....	36
1887	25	9	7	1	.....	1	.....	.....	.....	.....	.....	.....	43	4	1	2	1	8	.....	.....	.....	.....	.....	.....	.....	51
1888	25	7	4	.....	.....	8	.....	.....	.....	.....	.....	1	45	4	1	3	.....	8	.....	.....	1	1	1	1	4	57
1889	22	5	5	2	.....	3	.....	.....	.....	.....	.....	.....	37	.....	.....	4	.....	4	.....	.....	.....	.....	.....	.....	.....	41
1890	25	7	1	1	.....	7	.....	.....	.....	.....	3	.....	44	.....	2	6	.....	8	.....	.....	.....	2	2	1	5	57
1891	22	8	1	3	3	4	.....	.....	.....	.....	.....	.....	41	2	.....	2	.....	4	.....	.....	.....	2	1	1	4	49
1892	29	12	6	2	.....	4	.....	.....	.....	.....	2	2	57	7	1	4	.....	12	.....	.....	.....	.....	.....	.....	.....	69
1893	42	9	5	1	.....	7	.....	.....	.....	.....	.....	.....	64	7	.....	6	1	14	1	.....	.....	1	2	1	5	83
1894	25	3	3	2	.....	14	1	.....	1	.....	.....	.....	49	2	1	2	.....	5	.....	.....	1	.....	1	1	3	57
1895	32	11	4	.....	.....	7	4	.....	.....	.....	.....	1	59	5	.....	8	1	14	1	.....	1	.....	2	1	5	78
1896	36	6	7	1	1	11	.....	.....	.....	.....	.....	.....	62	6	.....	1	.....	7	.....	.....	.....	.....	.....	1	1	70
1897	33	11	.....	5	.....	12	1	.....	.....	.....	1	1	64	4	.....	.....	1	5	.....	.....	1	1	1	1	4	73
1898	52	7	6	.....	.....	8	2	.....	.....	.....	1	.....	76	6	.....	4	.....	10	1	.....	2	.....	1	.....	4	90
1899	32	7	7	.....	.....	15	.....	.....	.....	2	.....	.....	63	.....	2	2	1	5	.....	.....	2	.....	2	1	5	73
1900	48	10	12	.....	.....	18	.....	.....	1	.....	1	1	91	3	1	4	.....	8	.....	.....	.....	.....	1	2	3	102
1901	52	8	12	1	.....	19	.....	.....	.....	.....	.....	.....	92	3	2	6	.....	11	1	.....	.....	.....	1	2	4	107
1902	42	12	16	.....	.....	24	.....	.....	.....	.....	.....	1	95	4	1	5	.....	10	.....	.....	.....	.....	1	1	2	107
1903	68	7	20	10	.....	40	.....	1	.....	.....	.....	.....	146	2	2	3	1	8	.....	.....	1	.....	1	2	4	158
1904	64	12	17	.....	.....	53	.....	1	.....	.....	.....	2	149	11	.....	6	.....	17	.....	.....	4	1	2	.....	7	173
1905	66	15	19	51	.....	25	.....	2	.....	.....	6	2	186	5	1	5	.....	11	.....	.....	2	.....	3	1	6	203
1906	66	17	23	3	2	20	.....	.....	.....	.....	.....	1	132	10	2	11	.....	23	.....	.....	.....	1	3	2	6	161
1907	73	20	39	5	.....	31	.....	2	1	.....	.....	3	174	4	3	1	.....	8	.....	.....	3	.....	7	.....	10	192
1908	61	21	27	3	.....	38	.....	1	.....	1	1	.....	153	6	1	1	.....	8	.....	1	2	.....	8	.....	11	172

1909	53	23	20	45	.....	34	.....	3	2	.....	259	2	440	.....	1	6	.....	7	.....	.....	2	1	5	3	11	456
1910	61	13	28	8	.....	9	.....	1	5	.....	.....	.....	135	4	3	6	.....	13	.....	.....	.....	1	3	1	5	113
1911	66	17	41	9	.....	15	1	3	1	.....	.....	1	134	5	.....	7	.....	13	.....	.....	1	1	1	3	6	178
1912	65	19	41	3	.....	11	.....	2	2	1	.....	.....	144	6	1	5	.....	13	1	.....	.....	1	3	2	7	183
1913	59	21	38	8	.....	11	1	3	1	.....	1	.....	133	2	1	1	.....	4	.....	.....	1	1	2	3	7	164
1914	49	20	38	55	.....	9	.....	2	.....	2	1	5	176	4	2	1	.....	6	.....	.....	2	.....	3	4	9	193

a Fiscal year ending June 30. "Other Causes" doubtless include fatalities belonging under other headings, but no information is available for a more detailed classification. The 24 fatalities under "Other Causes" in 1883 include 60 deaths due to inrush of water at the Diamond mine, Braidwood, Ill., Feb. 16, 1883.

INDIANA.

AREA AND DISTRIBUTION OF COAL FIELDS.

The coal-bearing area of Indiana amounts to about 6,500 square miles and includes 26 counties in the southwestern portion of the State. Nineteen of these counties are producing coal on a commercial scale. The coal measures contain over 20 horizons, in which coal beds of varying thickness have been found. Of these eight are of workable thickness over much or all of the field and several others are locally of workable thickness. In the center of the field as many as seven or eight beds are workable in a single area. Ordinarily over most of the field not more than three workable beds will be found.

The coal measures in Indiana have a total thickness of approximately 1,300 feet. Of these 1,300 feet there are 600 feet of barren beds at the top, a 500-foot interval which contains most of the workable coals, followed in descending order by 200 feet or more of rocks consisting mainly of sandstone.

CHARACTER OF COAL BEDS.

The eight different coal beds mined vary from 3 to 9 feet in thickness. The coal in the eastern part of the field is called block coal or semiblock because of its breaking into rectangular blocks. It is very pure, noncoking coal. The strictly "block coal" is found in Fontaine, Parke, Clay, and Owen Counties. South of that the coals in the easternmost counties are semiblock. The block coal occurs in small basins which vary in extent from a few acres to several square miles, owing to the irregular surface of the rocks upon which they were laid down. The coal may be 3 to 5 feet thick in the center of a basin but thins out gradually toward the edges. The western counties of the Indiana field contain bituminous coal. The bituminous beds vary from 3 to 10 feet in thickness, most of the workings being in beds over 5 feet thick. In 1910, 26 mines were mining coal from beds over 7 feet thick. These coals lie regularly with a slight pitch to the west and southwest, and in many parts of the field are regular in thickness. Practically all of the mines have a clay floor and shale roof. The No. 5 coal is overlain with black shale, commonly broken with pyrite concretions, that locally will hold up indefinitely over a 40-foot room without any posts. Most of the beds, however, have roofs of shale that tends to disintegrate rapidly in the summertime, especially in the air passages, and requires close posting.

MINING METHODS.

The earliest records of coal production in Indiana are for 1840, when 9,682 tons were mined. The production increased gradually until in 1913 it was 17,165,671 tons.

Most of the commercial mines are opened by shafts varying from 50 to 450 feet deep, only a few being opened by slopes and drifts. From the shafts the mines are opened by main entry and air course, each 8 feet wide, separated by a 12-foot pillar. The coal is mined almost exclusively by the room-and-pillar method, which varies in detail in different districts and even in different coal beds of the same district. The mines are usually well equipped with the latest appliances, including electric machines and self-dumping cages.

Mining machines were first used in 1884. The "block coal" was first successfully mined by machines in 1894. In 1891 there were 47 mining machines in operation and in 1913 there were 732 which produced 56.7 per cent of the coal mined during the year. Of the total number of machines used 365 were of the chain-breast type. The average production per machine in 1913 was 13,302 tons.

About 30 per cent of the coal mined is shot off the solid; hand mining produced only about 11 per cent of the total output in 1913.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

An act approved March 8, 1879, which became effective May 1, 1879, authorized the governor to appoint a mine inspector, whose duty was to inspect each coal mine in the State at least twice a year. The inspector was required to render annual reports to the governor and to state therein the number of mines operating, the production of each mine, and such other information as the inspector deemed necessary. On February 26, 1889, the department of geology and natural science was created and placed under the supervision of a director, who was also the State geologist. The department consisted of four divisions: Geology and natural science, mines and mining, mineral oils, and natural gas. The chief of each division was appointed by the geologist. The office of mine inspector was abolished, and the chief of the division of mines and mining, to be known as the inspector of mines, was directed to perform all duties previously performed by the mine inspector. Annual reports of the inspector were included in the annual reports of the department. The inspector was authorized to employ one assistant.

An act approved March 2, 1891, covering coal mines employing 10 or more men, made it the duty of mine operators to report, under penalty, all mine accidents causing death, and upon receipt of such a

notice the inspector and coroner were required to investigate the cause of the accident. The act of March 4, 1891, restricted the appointment of inspector of mines to persons who had passed an examination satisfactory to the State geologist. On March 6, 1897, an act was approved directing mine operators to report to the inspector all accidents which prevented the usual working of a mine for 24 consecutive hours, or resulted in injuries causing death or requiring the attendance of a physician or surgeon. On March 11, 1901, the number of assistants to the inspector was increased to two, and on March 9, 1907, the number was further increased to four. The latter act also required that each mine should be inspected at least three times each year.

An act approved March 6, 1911, created a bureau of inspection, to consist of three departments: Inspection of mines, inspection of boilers, and inspection of factories. The new bureau was placed under the supervision of a chief inspector appointed by the governor. The governor also appointed three deputies, one for each of the departments comprising the bureau. Each deputy inspector was authorized to appoint five assistants, with the approval of the chief inspector.

Up to 1915 it was the practice of operators of mines employing 10 or more men to report to the inspector all accidents causing death or requiring the attendance of a physician or surgeon, and all such accidents were published in the inspector's annual reports. Injuries causing disability for two weeks were classified as serious, all others being considered slight.

The legislature of 1915 passed a workmen's compensation act, effective September 1, 1915, to be administered by the Industrial Board of Indiana, which was also provided for by the act. The department of inspection of mines and mining was transferred to the industrial board. Under the compensation law all employers of labor are required under penalty to report to the board all accidents causing injury to an employee whereby the employee is incapacitated for work more than one day. The department of mines, under the jurisdiction of the industrial board, consists of one chief inspector and five assistants, who are appointed by the board with the concurrence of the governor.

ACCIDENTS.

The accompanying tables show the total number of fatalities by causes and calendar years since 1881 as compiled from State mine inspectors' reports. They also show the percentage of accidents, by principal causes, and the fatality rate per 1,000 men employed for a period of 19 years for which continuous records are available. The fatality rate during this period is 2.16 per 1,000 men employed.

FATALITIES IN INDIANA COAL MINES, BY PRINCIPAL CAUSES, DURING THE YEARS 1895 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	306	45.07	0.97
Mine cars and locomotives	75	11.04	.24
Gas and dust explosions	57	8.39	.18
Explosives	132	19.44	.42
Miscellaneous	22	3.24	.07
Shaft	71	10.46	.23
Surface	16	2.36	.05
Total, 19 years	679	100.00	2.16

COAL-MINE ACCIDENTS IN INDIANA IN WHICH 5 OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Nature of accident.	Killed.
1878 Nov. 21	Sullivan	Sullivan	Mine explosion	8
1896 Dec. 26	Oswald	Princeton	do	7
1905 Mar. 22	do	do	Powder and mine explosion.	9
1907 Jan. 14	Deering No. 7	Clinton	Powder explosion	7
1909 Mar. 20	Sunnyside	Evansville	Mine explosion	6

Indiana has been fortunate in that it has had but few disasters (only four) during this period in which 5 or more men were killed at one time, the total number being 29 fatalities, or slightly over 4 per cent of the entire number. To offset this, however, there were 132 fatalities due to explosives, representing 19.44 per cent of the total. The average production of coal per fatality during this period was 291,062 tons, or 3.44 fatalities per million tons mined.

Indiana, like Illinois, is an 8-hour State, and in order to make it comparable with other States, where 9 or 10 hours are considered a working day, a table has been compiled whereby the time element has been taken into consideration. The fatality rate for the 10-year period 1903–1913 (Table 40) based on the actual number of employees

NUMBER OF HOURS TO THE WORKING DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN INDIANA.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, or 10 hours per day.	Total number of men employed.
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	236	16,291	5	24	6	39	663	17,017
1904	244	18,727	7	44	4	16	800	19,587
1905	271	24,484	2	24	3	15	800	25,323
1906	230	19,842	2	100	.....	.....	1,028	20,970
1907	208	18,323	.....	.....	.....	.....	2,699	21,022
1908	207	18,040	.....	.....	1	5	335	18,380
1909[b]	.....	.....	.....	.....	.....	.....	.....	20,937
1910	215	20,783	4	16	3	14	1,065	21,878
1911	213	20,946	2	7	3	16	22	20,991
1912	211	21,220	1	6	5	109	316	21,651
1913	199	21,637	3	42	6	121	435	22,235

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN INDIANA, AND THE FATALITY RATE, BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day (all employees).	Total hours per year.	Number of 2,000-hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	197	136,901	26,969,497	13,485	52	3.86
1904	177	157,572	27,890,244	13,945	34	2.44
1905	151	203,438	30,719,138	15,360	46	2.99
1906	175	168,888	29,555,400	14,778	31	2.10
1907	197	170,875	33,662,375	16,831	53	3.15
1908	174	147,385	25,644,990	12,822	45	3.51
1909	.....	.....	.....	.....	49	.....
1910	229	176,133	40,334,457	20,167	51	2.53
1911	182	167,989	30,573,998	15,287	46	3.01
1912	182	173,748	31,622,136	15,811	35	2.21
1913	190	178,599	33,933,810	16,967	66	3.89
1914	.....	.....	.....	.....	.....	.....

is 2.20 as compared with 2.95 on the 2,000-hour basis. Table 40 gives all of the States on this basis for the 10-year period, so that a comparison with other States may be made. During this period the men worked 1,487 hours per year as compared with 2,034 hours for the bituminous fields of Pennsylvania.

The tables of statistics for the State of Indiana follow.

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN INDIANA.[a]

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899	3,272	132,825	40	1907	3,176	42,842	13
1900	3,583	71,282	20	1908	7,076	157,899	22
1901	1,027	40,812	39	1909	36	720	20
1902	1,824	23,693	13	1910	12,638	423,894	34
1903	2,680	46,560	17	1911	4,577	146,636	32
1904	1,061	22,963	18	1912	15,400	795,887	52
1905	981	12,528	13	1913	2,657	44,143	17
1906	15,875	995,217	63	1914	8,052	302,855	38

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 97.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN INDIANA, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.[a]

[Figures for total production and all items below horizontal lines in various columns selected from Mineral Resources, U. S. Geol. Survey. Figures in column 4 and all items above horizontal lines in columns 2, 3, 20, and 21 from State mine inspectors' reports. Figures in columns 5, 6, and 7 and averages in columns 9 and 10 prior to 1900 calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial ax or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1840–1878	11,150,832	.....	.....	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1879	1,196,490	.....	3,459	.....	.....	.....	.....	.....	371	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	62
1880	1,454,327	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1881	1,984,120	.....	4,567	10	2.19	5.04	198,412	.....	434	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1882	1,976,470	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1883	2,560,000	.....	5,403	11	2.04	4.30	232,727	.....	474	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1884	2,260,000	.....	5,716	9	1.57	3.98	251,111	.....	395	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1885	2,375,000	$1.15	6,502	7	1.08	2.95	339,286	(b)	365	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1886	3,000,000	1.15	6,406	7	1.09	2.33	428,571	(b)	468	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1887	3,217,711	1.34	.....	.....	.....	.....	.....	(b)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1888	3,140,979	1.40	6,685	17	2.54	5.41	184,763	(b)	470	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1889	2,845,057	1.02	6,448	.....	.....	.....	.....	(b)	441	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1890	3,305,737	.99	5,489	5	.91	1.51	661,147	220	602	2.74	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1891	2,973,474	1.03	5,879	5	.85	1.68	594,695	190	506	2.66	.....	.....	.....	.....	.....	.....	.....	.....	.....	47	.....
1892	3,345,174	1.08	6,436	19	2.95	5.68	176,062	224	520	2.32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1893	3,791,851	1.07	7,644	22	2.88	5.80	172,357	201	496	2.47	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	97
1894	3,423,921	.96	8,603	.....	.....	.....	.....	149	398	2.67	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1895	3,995,892	.91	8,530	23	2.70	5.76	173,734	189	468	2.48	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1896	3,905,779	.84	8,806	28	3.18	7.17	139,492	163	444	2.72	.....	24.7	.....	.....	.....	.....	.....	.....	.....	186	.....
1897	4,151,169	.84	8,886	16	1.80	3.85	259,448	170	467	2.75	.....	24.7	.....	.....	.....	.....	.....	.....	.....	174	137
1898	4,920,743	.81	8,971	21	2.34	4.27	234,321	199	549	2.76	.....	28.7	.....	.....	.....	.....	.....	.....	.....	233	.....
1899	6,006,523	.82	9,712	16	1.65	2.66	375,408	218	618	2.83	.....	28.5	.....	.....	163	84	.....	.....	.....	247	.....
1900	6,484,086	1.03	11,720	19	1.62	2.93	341,268	199	553	2.78	.....	27.4	.....	.....	.....	.....	.....	.....	.....	254	160
1901	6,918,225	1.01	12,968	24	1.85	3.47	288,259	194	533	2.75	.....	26.8	.....	.....	.....	.....	.....	.....	.....	256	162
1902	9,446,424	1.10	15,457	24	1.55	2.54	393,601	205	611	2.98	.....	25.6	.....	.....	.....	.....	.....	.....	.....	269	166

1903	10,794,992	1.23	17,017	52	3.06	4.82	207,590	197	634	3.22	.....	30.9	.....	.....	110	219	.....	.....	.....	329	184
1904	10,842,189	1.11	19,587	34	1.74	3.14	313,888	177	554	3.13	.....	33.3	.....	.....	139	269	1	.....	.....	409	210
1905	11,895,252	1.05	25,323	46	1.82	3.87	258,592	151	470	3.11	.....	35.4	.....	.....	142	362	2	.....	.....	506	208
1906	12,092,560	1.08	20,970	31	1.48	2.56	390,083	*175	577	3.30	.....	35.2	.....	.....	124	329	18	.....	.....	471	200
1907	13,985,713	1.08	21,022	53	2.52	3.79	263,881	197	665	3.38	.....	38.0	.....	.....	147	308	58	.....	.....	513	204
1908	12,314,890	1.06	18,380	45	2.45	3.65	273,664	174	670	3.85	.....	43.0	.....	.....	140	332	35	.....	.....	507	204
1909	14,834,259	1.02	20,937	49	2.34	3.30	302,740	(b)	709	(b)	.....	50.0	.....	.....	227	391	13	.....	.....	631	296
1910	18,389,815	1.13	21,878	51	2.33	2.77	360,585	229	841	3.67	.....	48.9	.....	.....	194	422	29	.....	.....	645	251
1911	14,201,355	1.08	20,991	46	2.19	3.24	308,725	182	677	3.72	7.7	49.6	38.0	4.7	166	426	30	45	.....	667	257
1912	15,285,718	1.14	21,651	35	1.62	2.29	436,735	182	706	3.88	13.7	54.7	30.2	1.4	198	348	99	42	.....	687	238
1913	17,165,671	1.11	22,235	66	2.97	3.84	260,086	190	772	4.06	10.9	56.7	30.1	2.3	166	365	105	96	.....	732	231
Total	251,632,098	.....	.....	799	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (1895–1913)	10,401,629	.....	16,581	35.74	2.16	3.44	291,062	187	627	3.35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	16,641,132	1.10	23,175	44	1.90	2.64	378,208	168	718	4.27	10.6	56.2	29.9	3.3	176	391	69	115	.....	751	225

a Figures in italics represent incomplete fatality records.

b Not reported.

TABLE 98.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN INDIANA, WITH FATALITIES CLASSIFIED ACCORDING TO CAUSE, DURING THE CALENDAR YEARS 1881 TO 1913, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.								Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1881 a												10	10													10
1882 b																										
1883 a												11	11													11
1884 a												9	9													9
1885 a												7	7													7
1886 a												7	7													7
1887 c																										
1888 a												17	17													17
1889 c																										
1890 a												5	5													5
1891	2		1			1							4										1		1	5
1892 a												19	19													19
1893	9	2	1	3		5							20										1	1	2	22
1894 c																										
1895	12		3			3							18	3		2		5								23
1896	9		3	9		2							22	2		3		5								33
1897	9		1			5							15	1				1								16
1898	13					5							18		1	1		2				1			1	21
1899	6		2			2						3	13	1		1	1	3								16
1900	11					3			1				15	2		1		3					1		1	19
1901	11	1	3			4							19	2		3		5								24
1902	11		3			7							21			2		2					1		1	24
1903	16	2	4	1		19		1			1	1	45	4		2		6					1		1	52
1904	13		6			9		1					29	2		2		4					1		1	34
1905	17		3	2	9	8						1	40	2		3		5					1		1	46
1906	19		3	1		4							27	1		2		3					1		1	31
1907	15	1	8	2		18			1			1	46	1		4		5					2		2	53
1908	19	3	6	1		10		1	1				41	1		3		4								45
1909	23	2	4		6	5				1		1	42	2	1	3		6					1		1	49

| | | |

IOWA.

AREA AND DISTRIBUTION OF COAL FIELDS.

The coal fields of Iowa are in the Pennsylvanian series of the Carboniferous system and occupy the central and southern part of the State. The total coal-bearing area is about 20,000 square miles, of which 13,000 square miles include outcropping coal beds that are considered workable under the present economic conditions. In 1913, 21 counties were reported as coal producers.

The principal producing areas are in Marion, Mahaska, Monroe, and adjacent counties, which produced 43 per cent of the coal in 1913; Polk, Jasper, and Dallas counties of the same group produced 32 per cent; and Appanoose and Wayne counties, containing the Mystic or Centerville bed, produced 17 per cent. This bed is very persistent over a considerable area.

CHARACTER OF COAL BEDS.

The Iowa coal is bituminous, non-coking, and contains a high percentage of sulphur in the form of pyrite. The coal is used largely for steaming purposes. Practically all of the beds are horizontal or dip about 10 feet per mile. Most of the coal beds are opened by shafts of different depths, as follows: Lucas County, 321 feet; Appanoose and Wayne counties, 200 feet; Adams County, 400 feet; Polk County, 156 feet; Webster County, 16 to 100 feet; and Marion County, 150 feet. There are a few slope and drift mines.

The coal beds of the Des Moines group (the lower part of the Pennsylvanian series) vary from 3½ to 5 feet or more in thickness and, with the exception of the Mystic bed, are somewhat faulted and irregular. The thickest coal in the State occurs in Marion County, where beds 4 to 12 feet thick have been opened. The Mystic or Centerville bed is about 2½ feet thick, has a strong roof, and is adapted to longwall mining methods.

MINING METHODS.

Coal mining in Iowa began about 1840, for which year the records show a production of 400 tons. The production has gradually increased until in 1913 it was 7,525,936 tons.

Nearly all of the mines are operated through shafts and the coal is mined by the longwall and room-and-pillar methods. In 1891, 9 machines were introduced into the mines and the number gradually increased to 56 in 1898. Since that date the number of machines has been gradually reduced. Of 62 mines in Appanoose County in 1904, 16 used the room-and-pillar method and 46 the longwall method. Longwall mining machines are used rather extensively. A large amount of coal is shot off the solid,but records showing the extent to

which this is practiced are not available prior to 1911. In 1912, 69 per cent, and in 1913, 72.3 per cent of the total production was shot off the solid. The hand-mined coal amounts to about 20 per cent of the total, while that produced by machines is less than 2 per cent.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

Section 1567 of the Iowa Code of 1873 directed that the board of supervisors of each county in which coal or other minerals were found should appoint an inspector of mines, who, upon application of mine owners, operators, or employees, examined the atmosphere of such mines as affecting life or health. If gas was found in sufficient quantities to jeopardize life or health, the inspector was authorized to require the operator to provide additional shafts or entrances for proper ventilation, and a penalty was provided for failure to carry out such demands of the inspector.

On March 18, 1874, the foregoing provisions were superseded by a law requiring the county inspectors, who were appointed as under the previous law, to examine each mine twice a year, provided more than 10 miners were employed therein. Operators were required, under penalty, to notify the inspector of all fatal and serious accidents, and, if fatal, to notify the county coroner also. The inspector was required to examine into the causes of accidents and to preserve a record of his inspections. The law of March 30, 1880, consolidated the inspection service under the jurisdiction of one State mine inspector appointed by the governor. The act applied only to mines employing more than 15 men, and the inspector was required to make an annual report to the governor, enumerating therein all accidents in and about the mines. An act approved March 18, 1884, extended the inspection law to cover all mines employing more than five men, and required the inspector to render biennial reports to the governor on August 15 preceding the regular session of the State legislature.

On April 10, 1886, the governor was authorized to divide the State into three districts and appoint a mine inspector for each district, the inspectors to report to the governor as before. A law of April 12, 1888, provided for a board of examiners to examine candidates for the office of mine inspector. By an act approved May 6, 1911, mine operators were required to report on August 1 of each year to the district inspector, for the year ending July 1, the number of employees in and around the mines, in addition to sending to the inspector an immediate notice of fatal and nonfatal accidents.

All injuries, whether serious or slight, are reported to the district mine inspectors, but only those causing disability for at least 10 days are considered serious injuries and published in the inspectors' annual reports.

ACCIDENTS.

The accompanying tables, Nos. 99 and 100, show the total number of fatalities by causes and calendar years since 1880, as compiled from the State mine inspectors' reports. These tables also show the percentage of accidents, classified by principal causes, and fatality rate per 1,000 men employed, over a period of 26 years for which

FATALITIES IN IOWA COAL MINES, BY PRINCIPAL CAUSES, DURING THE YEARS 1888 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	426	59.00	1.31
Mine cars and locomotives	76	10.53	.23
Gas and dust explosions	44	6.10	.13
Explosives	74	10.25	.23
Miscellaneous	18	2.49	.06
Shaft	65	9.00	.20
Surface	19	2.63	.06
Total, 26 years	722	100.00	2.22

COAL-MINE ACCIDENTS IN IOWA IN WHICH 5 OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Nature of accident.	Killed.
1903, Feb. 14	Chicago and Iowa	Albia	Mine explosion	8
1902, Jan. 24	Lost Creek No. 2	Oskaloosa	Do.	20

continuous records are available. The fatality rate during this period is 2.22 per 1,000 men employed. Iowa has been fortunate in that there have been but two disasters, in which five or more men were killed at one time. The fatalities represented by these two disasters are only 4 per cent of the total number killed during the above period. Of the total number of fatalities, 59 per cent were due to falls of roof and pillar coal, 10.53 per cent to mine cars and locomotives, and 10.25 per cent to explosives. The average production of coal per fatality during this period was 204,390 tons, or 4.89 fatalities for each million tons mined.

Since Iowa is an eight-hour State, the time element has been taken into consideration, and tables have been compiled on this basis for comparison with other States. The fatality rate for the 10-year period, 1903–1913 (Table 40), based upon the actual number of employees, is 1.94, whereas based on the number of 2,000-hour workers it is 2.27. During the 10-year period the men averaged 1,704 hours per year, as compared with 2,447 hours for Virginia. Table 41 shows

NUMBER OF HOURS TO THE WORKING DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN IOWA.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, or 10 hours per day.	Total number of men.
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	237	12,689	3	27	.....	.....	1,446	14,162
1904	261	15,221	1	10	1	10	388	15,629
1905	186	13,569	5	56	3	22	1,466	15,113
1906	195	14,869	2	20	1	8	363	15,260
1907	175	15,171	1	10	.....	.....	404	15,585
1908	218	14,772	3	28	4	24	1,197	16,021
1909[b]	.....	.....	.....	.....	.....	.....	.....	17,236
1910	220	16,238	2	10	3	11	407	16,666
1911	196	16,095	3	16	.....	.....	741	16,852
1912	194	15,806	1	9	1	4	551	16,370
1913	185	15,248	2	16	1	12	481	15,757

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN IOWA AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day. (All employees.)	Total hours per year.	Number of 2,000-hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	226	114,769	25,937,894	12,969	27	2.08
1904	213	125,450	26,720,850	13,360	25	1.87
1905	209	122,470	25,596,230	12,798	37	2.89
1906	224	122,479	27,435,296	13,718	29	2.11
1907	230	125,094	28,771,620	14,386	40	2.78
1908	214	129,441	27,700,374	13,850	31	2.24
1909[a]	.....	.....	.....	.....	.....	.....
1910	218	133,767	29,161,206	14,581	33	2.26
1911	203	135,573	27,521,319	13,761	38	2.76
1912	188	131,528	24,727,264	12,364	19	1.54
1913	195	126,577	24,682,515	12,341	26	2.11

[a] Census year.

the fatality rate for each year on the 2,000-hour basis (1903–1913) for each State, so that a true comparison of Iowa with other States may be readily made. The tables of statistics for the State of Iowa follow:

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN IOWA.[a]

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899	2,623	72,710	28	1907	1,621	8,265	5
1900	1,322	62,333	47	1908	5,248	121,087	23
1901	401	16,171	40	1909	2,036	12,504	6
1902	363	6,480	18	1910	9,209	408,563	44
1903	1,143	11,365	99	1911	1,622	31,870	20
1904	8,303	173,781	21	1912	8,455	370,449	44
1905	1,774	10,353	6	1913	721	13,538	19
1906	7,969	204,860	28	1914	2,642	76,791	29

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 99.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN IOWA, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.

[Figures for total production and all items below horizontal lines in various columns selected from Mineral Resources, U. S. Geol. Survey. Figures in column 4 and all items above horizontal lines in columns 2, 3, 11, and 20 from State mine inspectors' reports. Figures for columns 5, 6, and 7, and averages in columns 9 and 10 prior to 1900 calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial axe or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1840–1879	10,061,992																				
1880	1,461,116			3		2.05	487,039														
1881	1,960,000																				
1882	3,920,000			22		3.74	267,273														
1883	4,457,540			15		3.37	297,169														
1884	4,370,566			22		5.03	198,662														
1885	4,012,575	$1.20		16		3.99	250,786														
1886	4,315,779	1.25		22		5.10	196,172														
1887	4,473,828	1.34		22		4.92	203,356														
1888	4,952,440	1.30	9,600	30	3.13	6.06	165,081														
1889	4,095,358	1.33	9,247	22	2.38	5.37	186,153														
1890	4,021,739	1.24	8,130	12	1.48	2.98	335,145	213	495	2.32											
1891	3,825,495	1.27	8,124	27	3.32	7.06	141,685	224	471	2.10		1.1	(a)	(a)							9
1892	3,918,491	1.32	8,170	21	2.57	5.36	186,595	236	480	2.03			(a)	(a)							
1893	3,972,229	1.30	8,863	24	2.71	6.04	165,510	204	448	2.20			(a)	(a)							
1894	3,967,253	1.26	9,995	24	2.40	6.05	165,302	170	397	2.34			(a)	(a)							
1895	4,156,074	1.20	10,066	23	2.28	5.53	180,699	189	413	2.19			(a)	(a)							
1896	3,954,028	1.17	9,672	18	1.86	4.55	219,668	178	409	2.30		2.1	(a)	(a)							45
1897	4,611,865	1.13	10,703	23	2.15	4.99	200,516	201	431	2.14		3.9	(a)	(a)							49
1898	4,618,842	1.14	10,262	22	2.14	4.76	209,947	219	450	2.05		4.7	(a)	(a)							56
1899	5,177,479	1.24	10,971	25	2.28	4.83	207,099	229	472	2.06		2.2	(a)	(a)	22	13	6			41	
1900	5,202,939	1.38	11,608	29	2.50	5.57	179,412	228	448	1.96		2.6	(a)	(a)						40	
1901	5,617,499	1.39	12,653	29	2.29	5.16	193,707	218	444	2.04		2.0	(a)	(a)						53	
1902	5,904,766	1.47	12,434	49	3.94	8.30	120,505	227	475	2.09		1.9	(a)	(a)						31	

1903	6,419,811	1.65	14,162	27	1.91	4.21	237,771	226	453	2.00	.....	.9	(a)	(a)	.....	11	.....	10	.....	.....	10	244
1904	6,519,933	1.61	15,629	25	1.60	3.83	260,797	213	417	1.96	.....	2.7	(a)	(a)	.....	9	10	18	.....	.....	39	267
1905	6,798,609	1.56	15,113	37	2.45	5.44	183,746	209	450	2.15	.....	2.7	(a)	(a)	.....	9	9	14	.....	.....	33	.....
1906	7,236,224	1.60	15,260	29	1.90	3.99	250,559	224	476	2.13	97.3	2.7	(a)	(a)	.....	11	14	9	.....	.....	34	.....
1907	7,574,322	1.62	15,585	40	2.57	5.28	199,353	220	436	2.11	98.6	1.4	(a)	(a)	.....	16	9	8	.....	.....	33	.....
1908	7,161,310	1.63	16,021	31	1.93	4.33	231,010	214	447	2.09	99.0	1.0	(a)	(a)	.....	19	9	.....	.....	.....	28	.....
1909	7,757,762	1.65	17,286	39	2.26	5.03	198,917	(b)	449	(b)	99.9	.1	(a)	(a)	.....	5	.....	.....	.....	.....	.....	309
1910	7,928,120	1.75	16,666	33	1.98	4.16	240,246	218	476	2.18	99.7	.3	(a)	(a)	.....	11	6	.....	.....	.....	17	268
1911	7,331,648	1.73	16,852	38	2.26	5.18	192,988	203	435	2.14	15.2	.6	68.4	15.8	.....	10	6	3	.....	1	20	237
1912	7,289,529	1.80	16,270	19	1.16	2.61	383,659	188	445	2.37	19.9	1.3	69.1	9.7	.....	16	3	3	1	1	24	219
1913	7,525,936	1.79	15,757	26	1.65	3.45	289,459	195	478	2.45	20.2	1.6	72.3	5.9	.....	8	7	8	8	2	28	208
Total	186,603,097	.....	.....	844	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (1888–1913)	6,676,753	.....	13,908	27.77	2.22	4.69	204,390	211	454	2.15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	7,451,022	1.79	16,057	37	2.30	4.97	201,379	204	464	2.27	19.5	4.1	74.4	2.0	2	4	18	21	1	46	190

a Included in hand mining, column 11.

b Not reported.

TABLE 100.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN IOWA, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE, DURING THE CALENDAR YEARS 1880 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1880 [a]	3												3													3
1881	9		2			6							17	2		3		5								22
1882																										
1883	8		1			1						1	11			3		3			1				1	15
1884	13		2								1	1	17			1	1	2			1	1			2	22
1885	10	1				1						2	14			2		2								16
1886	10	1	2			5							18			1		1				3			3	22
1887	13	1				4							18	1		2		3				1			1	22
1888	10	2	2			9						1	24	2	1	2		5					1		1	30
1889	11	2	2			2							17	1		4		5								22
1890	4	1	1			3							9	1		1		2					1		1	12
1891	19	2				4							25			1		1				1			1	27
1892	13		1		3	2							19	1				1						1	1	21
1893	12	2			8	1							23			1		1								24
1894	12	1	3			3							19	1		1		2				2	1		3	24
1895	11	2	1				4				2		20	2				2					1		1	23
1896	9		2		2	3							16	2				2								18
1897	12	2	1			2			1				18	3		1		4				1			1	23
1898	14	1	3			3							21									1			1	22
1899	13	1	1			3							18	5	1		1	7								25
1900	17		5			2							24	2	1	1		4	1						1	30
1901	14	7	2		2	3							28	1				1								29
1902	15	2	2		22	5						1	47			1		1					1		1	49
1903	16	2	3			3							24	3				3								27
1904	11	2	2		2	1	1						19		2	3		5						1	1	25
1905	24	1	4			5						1	35	1				1	1					1	1	37
1906	14	1	6			5							26	2				2						1	1	29
1907	21	7	2	1	1	2							34	1		3		4				1	1		2	40
1908	16	3	4			3							26	2	1	2		5								31

| | | |

KANSAS.

AREA AND DISTRIBUTION OF COAL FIELDS.

The coal-bearing measures of Kansas comprise about 18,600 square miles, of which 3,100 square miles are known to contain workable coal beds. The coal-bearing area occupies a strip covering about 3 to 4 counties wide entirely across the eastern end of the State, but the best beds are found in Cherokee and Crawford counties in the southeast corner.

The coal beds of this State belong to the Carboniferous system and occur in the southwest extension of the coal-bearing rocks of the Iowa-Missouri field. About 90 per cent of the coal mined in the State is from the Weir-Pittsburgh beds in Crawford and Cherokee counties. About 6 per cent of the coal is produced in the Atchison-Leavenworth district from a depth of 700 feet to 1,150 feet.

CHARACTER OF COAL BEDS.

The coal beds of Crawford and Cherokee counties are practically horizontal, and occur at depths of 30 feet to 250 feet. The coal is bituminous, and produces a large amount of dust when mined. The beds vary in thickness from 3 to 10 feet, those in the Cherokee shale being very irregular. The thicker parts of the workable beds lie in "swamps" or basins of very irregular outline. Rolls in the floor and roof cause differences of level of 20 to 30 feet in many of the mines and a difference of as much as 60 feet has been observed in a single mine. It seems that these irregularities are due to unevenness of the original bottom upon which the coal was formed.

MINING METHODS.

The earliest statistics of coal production in Kansas are for 1869, when 36,891 tons were mined. In 1913, the production was 7,202,210 tons. Practically all of the coal is mined by the room-and-pillar system, but some longwall mining is done in Osage County. About 85 per cent of the mines are opened by shaft; 11 per cent are strip pits, and 4 per cent are drift mines. In southeastern Kansas considerable coal is mined by stripping with a steam shovel. In places as much as 40 feet of cover is removed in stripping.

Mining machines were introduced into Kansas about 1897 but their use has been confined to a limited number of mines. In 1908, there were 17 machines in use; in 1913, only 9 were used, producing 0.3 per cent of the coal mined in the State, 14.8 per cent was mined by hand, and 85.5 per cent was shot off the solid.

The State mine inspector in his report for 1913 states that in Crawford and Cherokee counties 982,546 12½-pound kegs of powder were

used, or one keg for every 7.22 tons of coal produced. In addition, he also estimates that 1,029,000 pounds of dynamite and 46,450 pounds of permissible powder were used.

He also states that:

> The extreme danger in the increased and excessive amount of explosives used is hereby made apparent and can not be gainsaid. Had these figures of dynamite and permissible powder been reversed the condition under which the mines were operated, in my opinion, would have been vastly improved as far as their safety is concerned. This may also account in a certain measure for the grade of coal produced at some of the mines.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

The governor of Kansas was authorized by an act approved February 27, 1883, to appoint an inspector of coal mines for two years from June 30, 1883. Mine operators were required to report to the inspector all accidents causing serious or fatal injuries, and, if fatal, to the coroner of the county in which the mine was located. A monthly report by the inspector, showing the number of accidents and deaths from injuries and number of men employed, was required to be filed with the secretary of the State board of agriculture on or before the first Monday in each month. The act of March 13, 1885, required the inspector to render annual reports to the governor on the 1st day of February of each year. The mine operators were required by the act of March 13, 1897, to render quarterly reports of accidents to the State mine inspector. The method of selecting the mine inspector was changed by an act approved January 6, 1899. By this act an association of miners was authorized, consisting of a delegate from each organized body of five or more miners in any county, city, or mining camp in the State. The State association held annual meetings and elected a president, vice president, and secretary, and the secretary so elected succeeded to the duties of State mine inspector.

On February 5, 1913, an act was approved creating a department of labor and industry under the control of a commissioner of labor and industry. The commissioner was made ex officio factory and mine inspector, with authority to appoint an assistant of at least five years' experience in coal mining. In 1914 the inspection of coal mines was carried on by the assistant commissioner and five deputies.

All injuries, whether serious or slight, are reported to the inspector and are included in his annual reports, but no definition is given as to what constitutes a serious or slight injury.

ACCIDENTS.

Tables 101 and 102 show, by causes and calendar years, the total number of fatalities since 1884, excepting 1886, 1888, and 1892, for which years reports are not available. These tables also show the percentage of accidents, classified by principal causes, and fatality rate per 1,000 men employed for a period of 21 years for which continuous records are available. The fatality rate during this period is 2.45 per 1,000 men employed. Of the total number killed

FATALITIES IN KANSAS COAL MINES, BY PRINCIPAL CAUSES, DURING THE YEARS 1893 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	259	49.05	1.20
Mine cars and locomotives	12	2.27	.06
Gas and dust explosions	33	6.25	.15
Explosives	131	24.81	.61
Miscellaneous	26	4.93	.12
Shaft	50	9.47	.23
Surface	17	3.22	.08
Total, 21 years	528	100.00	2.45

COAL-MINE ACCIDENTS IN KANSAS IN WHICH 5 OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Nature of accident.	Number killed.
1888 Nov. 9	Shaft No. 2	Frontenac	Mine explosion	40
1906 Dec. 20	Fidelity No. 1	Stone City	Powder explosion	7
1911 Mar. 18	No. 16	Mineral	Mine explosion	5
1914 Jan. 14	Spencer-Newland	Mulberry	Cage with men fell down shaft.	6

(1893–1913), 49.05 per cent of the fatalities were due to falls of roof and pillar coal, and 24.81 per cent to explosives. The amount of coal mined by shooting off the solid is approximately 80 per cent of the total production. The average production of coal per fatality during the 21 years was 203,153 tons, or 4.92 fatalities for each million tons mined. The average production per man a year was 497 tons, or 2.56 tons per day.

During the period 1884 to 1913, inclusive, there were three mine disasters in which 52 men were killed, representing slightly less than 8½ per cent of the total number killed in the coal mines of Kansas.

In Kansas, more than 95 per cent of the men are on an eight-hour basis, and for comparative purposes the time element has been taken into consideration and tables compiled. It will be noted that the fatality rate for the 10-year period, 1903–1913 (Table 40), based on actual number of employees, was 2.70 per 1,000 men employed, and reduced to a 2,000-hour basis was 3.45 per 1,000. Table 41 shows

NUMBER OF HOURS TO THE WORKING DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN KANSAS.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, or 10 hours per day.	Total number of men employed.
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	145	9,965	9	447	8	62	450	10,924
1904	151	11,599	9	215	5	45	339	12,198
1905	121	11,004	6	129	5	54	739	11,926
1906	141	12,606	7	94	3	390	1,256	14,355
1907	134	10,980	10	156	1	10	1,293	12,439
1908	138	12,973	11	283	7	363	297	13,916
1909[b]								12,350
1910	126	12,255	9	115	1	5	495	12,870
1911	121	10,989	7	177			657	11,823
1912	132	11,186	7	380			80	11,646
1913	138	12,240	1	5			234	12,479

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN KANSAS, AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day (all employees).	Total hours per year.	Number of 2,000-hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	215	88,413	19,008,795	9,504	33	3.47
1904	213	98,228	20,922,564	10,461	31	2.96
1905	212	96,334	20,433,408	10,217	41	4.01
1906	165	116,988	19,303,020	9,652	39	4.04
1907	225	100,981	22,720,725	11,360	37	3.26
1908	181	112,634	20,386,754	10,193	38	3.73
1909						
1910	148	103,580	15,329,840	7,665	17	2.22
1911	190	95,418	18,129,420	9,065	42	4.63
1912	202	93,628	18,912,856	9,456	30	3.17
1913	197	100,071	19,713,987	9,857	28	2.84

the fatality rate for each year on the 2,000-hour basis (1903–1913) for each State, so that a true comparison of Kansas with other States may be readily made.

The tables of statistics for the State follow.

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN KANSAS.[a]

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899	1,986	88,798	45	1907	923	16,957	18
1900	157	3,560	23	1908	11,155	665,224	60
1901	60	300	5	1909	4,715	71,566	15
1902	334	17,256	52	1910	10,346	1,578,027	153
1903	328	2,516	8	1911	984	8,507	9
1904	186	1,214	7	1912	2,088	13,487	65
1905	1,482	14,686	10	1913	3,178	28,936	9
1906	11,827	709,422	59	1914	2,673	45,257	17

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 101.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN KANSAS, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.[a]

[Figures for total production and all items below horizontal lines in various columns selected from Mineral Resources, U. S. Geol. Survey. Figures in column 4 and all items above horizontal lines in columns 2 and 3 from State mine inspectors' reports. Figures in columns 5, 6, and 7, and averages in columns 9 and 10 prior to 1900, calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial ax or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1869–1883	5,068,071																				
1884	1,100,000			3		2.73	366,667														
1885	1,212,057		4,175	9	2.16	7.43	134,673		290												
1886	1,400,000																				
1887	1,596,879			6		3.76	266,147														
1888	1,850,000	$1.50	3,600	40					514												
1889	2,221,043	1.48	5,956	12	2.01	5.40	185,087	(b)	373												
1890	2,259,922	1.30	4,523	8	1.77	3.54	282,490	210	500	2.38											
1891	2,716,705	1.31	6,201	11	1.77	4.05	246,973	222	438	1.97											
1892	3,007,276	1.32	6,559	(b)				208	458	2.20											
1893	2,652,546	1.27	7,310	14	1.92	5.28	189,468	147	363	2.47											
1894	3,388,251	1.23	7,339	24	3.27	7.08	141,177	164	462	2.82											
1895	2,926,870	1.20	7,482	11	1.47	3.76	266,079	159	391	2.46											
1896	2,884,801	1.15	7,127	12	1.68	4.16	240,400	168	405	2.41											
1897	3,054,012	1.18	6,639	6	.90	1.96	509,002	194	460	2.37		0.2									1
1898	3,406,555	1.09	7,197	17	2.36	4.99	200,386	194	473	2.44		.3									2
1899	3,852,267	1.16	8,000	16	2.00	4.15	240,767	226	482	2.13		1.0				3					3
1900	4,467,870	1.22	8,459	21	2.48	4.70	212,756	232	528	2.28		1.0									3
1901	4,900,528	1.22	9,928	11	1.11	2.24	445,503	224	494	2.21		.8									4
1902	5,266,065	1.30	9,461	28	2.96	5.32	188,074	220	557	2.53		.9									6
1903	5,839,976	1.52	10,924	33	3.02	5.65	176,969	215	535	2.49		.2				3	2				5
1904	6,333,307	1.52	12,198	31	2.54	4.89	204,300	213	519	2.44		.2			3		2				5
1905	6,423,979	1.46	11,926	41	3.44	6.38	156,682	212	539	2.54		.3			10						10
1906	6,024,775	1.49	14,355	39	2.72	6.47	154,481	165	420	2.55		.5			6						6

1907	7,322,449	1.52	12,439	37	2.97	5.08	197,904	225	589	2.62	.....	.5	.....	.....	3	.....	.....	6	.....
1908	6,245,508	1.49	13,916	36	2.73	6.08	164,355	181	449	2.48	.....	2.1	.....	.....	10	7	.....	17	.....
1909	6,986,478	1.44	12,359	32	2.59	4.58	218,327	(a)	565	(a)	.....	.9	.....	.....	14	2	.....	16	194
1910	4,921,451	1.61	12,870	17	1.32	3.45	289,497	148	382	2.58	.....	.7	.....	.....	11	2	.....	13	155
1911	6,178,728	1.53	11,823	42	3.55	6.80	147,113	190	523	2.75	5.6	1.7	76.6	14.1	15	.....	.....	15	159
1912	6,986,152	1.62	11,646	30	2.58	4.29	232,873	202	600	2.97	5.9	1.1	83.9	9.1	9	.....	2	11	153
1913	7,202,210	1.67	12,479	28	2.24	3.89	257,222	197	577	2.93	14.8	.3	80.5	4.4	5	1	3	9	152
Total	129,606,761	.....	.....	617	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (1893–1913)	5,107,848	.....	10,280	25.14	2.45	4.92	208,183	194	497	2.56	.....	.6	76.9	6.1	.....	.....	7	2	.....	9	129
1914	6,880,988	1.63	12,448	.33	2.65	4.81	207,900	192	551	2.87	16.4	.6	76.9	6.1	.....	.....	.....	.....	.....	9	129

a Figures in italics represent incomplete fatality records.

b Not reported.

TABLE 102.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN KANSAS, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE, DURING THE CALENDAR YEARS 1884 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1884												3	3													3
1885	2					5							7			2		2								9
1886 a																										
1887	2				3								5	1				1								6
1888 a					40								40													40
1889	6	2				3							11			1		1								12
1890	4					1							5			3		3								8
1891	7		1			2						1	11													11
1892 a																										
1893	3		1			2						5	11	1		2		3								14
1894	10				2	4							16	3		2		5					2	1	3	24
1895	5					1		1				1	8			3		3								11
1896	5					5							10			2		2								12
1897	3					2							5		1			1								6
1898	7				3	5						2	17													17
1899	8					5						1	14			1		1			1				1	16
1900	12					6						1	19		1	1		2								21
1901	4					2						1	7	1	1	2		4								11
1902	12		2			7	1					1	23	3	2			5								28
1903	19					7						2	28	1		1		2					3		3	33
1904	15		2			11							28	1		2		3								31
1905	23		1		2	13							39	1				1					1		1	41
1906	14	1	1			20							36	1	1			2	1							39
1907	21		1	1	3	6							32	1		2		3					1	1	2	37
1908	22			1	3	6							32	1		3		4			1			1	2	38
1909	18		1	3		8			1				31			1		1								32
1910	7		1		1	3							12	4				4						1	1	17
1911 b	20			7	3	3	3	1				3	40	1				1				1			1	43

| | | |

KENTUCKY.

AREA AND DISTRIBUTION OF COAL FIELDS.

The two coal fields of Kentucky are located in the extreme eastern and western parts of the State.

The Eastern coal field has an area of about 10,270 square miles, of which about 70 per cent may be considered as productive. The rocks in this field are practically horizontal, except those in Bell and Harlan counties, which lie in the great synclinal trough east of Pine Mountain. In the middle of this trough the coal beds are flat-lying, but on either rim they dip steeply toward the axis of the trough. The stresses which caused the great trough have produced several minor folds in its bottom and also a few faults, which cause considerable trouble and expense in mining. The principal producing counties are Bell, Floyd, Harlan, Johnson, Knox, Laurel, Lee, Letcher, Perry, Pike, and Whitley. In 1913, the field produced 11,098,906 tons, as compared with 8,517,640 for the Western field.

The Western field is a continuation of the Indiana-Illinois field and has a coal-bearing area of about 6,400 square miles, of which 65 per cent may be considered as productive. This field, which includes Butler, Daviess, Hancock, Henderson, Hopkins, McLean, Muhlenberg, Ohio, and Webster counties, is the southeastern part of the big flat basin that carries the coal of Indiana and Illinois, but the rocks are much more disturbed in the Kentucky part than they are in those parts lying in the other States. The line of disturbance, extending in an east-west line across southern Illinois, continues across the western Kentucky field. Along this line from Shawneetown, Illinois, to Litchfield in Grayson County, the rocks are tilted and broken by faults to such an extent that mining is difficult and expensive.

CHARACTER OF COAL BEDS.

The Eastern field belongs to the Pottsville group of the Allegheny formation and contains 12 or more coal beds of workable thickness and quality. The coal of these beds is usually of high-grade gas or coking quality and some of it is cannel coal. The Blue Gem and Jellico beds, which extend into Tennessee, average about 22 inches thick. This coal is extensively mined and finds a ready market as a domestic and steam fuel. Other coal beds contain 8 to 9 feet of workable coal. In Breathitt County one of the coal beds that is extensively worked is 30 inches thick and has a thin shale roof above which is a stratum of limestone. In Pulaski County, one of the important beds is 35 inches thick and has a dip of about 1 per cent. In Bell County, one of the most productive beds is 36 to 42 inches thick and is horizontal.

There are three important coal beds that are worked in various parts of the western district. Coal A (No. 12) is about 80 inches thick at the Pierce mine in Muhlenberg County, it is of excellent steaming quality and has been used to a limited extent for coking, but is not of commercial importance for this use. The thickness of this bed varies and in general the roof is fire clay and shale. Coal B (No. 11), known also as the Danville bed, is one of the principal sources of commercial coal. It varies in thickness from 12 to 84 inches and is cut by clay slips and disturbed by rolls. It is 40 to 100 feet below the surface and is 25 feet below the No. 12 coal. At the Pierce mine, Muhlenberg County, the coal is 78 inches thick, and in Hopkins County, is about 84 inches thick. At Madisonville there is a thin stratum of shale between the coal and a limestone capping, whereas at Nortonville the limestone rests directly on the coal. Bed D (No. 9, equivalent of No. 5, Illinois) is more regular than the other coal beds and produces about 75 per cent of the coal of the western district. It is 56 to 60 inches thick and extends throughout the larger part of 8 counties. It is about 300 feet below the surface and is opened by shafts. Coal Fb (No. 5), also known as the "Four-foot" coal, is extensively mined at De Koven, Union County, where it has a maximum thickness of 54 inches. The roof is black shale 1½ to 2 feet thick. There are a number of other coal beds in the State, varying in thickness from a few inches to 40 and 50 inches, some of which are worked.

MINING METHODS.

Coal mining in Kentucky began in a small way in 1828, during which year 328 tons were reported as the annual production. The production has gradually increased until in 1913 it was 19,616,600 tons. The majority of the coal is mined by the double-entry, room-and-pillar method. In the eastern part of the State practically all of the mines are opened by drift or slope, whereas in the western field there are a number of shaft mines. In 1900 there were 23 shaft mines in the State, the others being opened by slopes or drifts. The following description[a] given by Dr. C. J. Norwood covers the mining methods of the year 1889.

Almost without exception, the mines of Kentucky are worked on the "pillar-and-room" system, with either single (with parallel air course) or double entry, usually the former. Sometimes one portion of the bank will be worked with single entry and another portion with double. The only two instances, known to the writer, in which long wall was tried resulted in failure; and one instance in which square work was attempted resulted in crushed pillars. The rooms are usually turned every 30 or 33 feet, and widened to from 18 to 21 feet. The necks are usually 6 to 12 feet long by 6 to 8 feet wide in the western field, and 8, 12, 18, or 20 feet long by 6 to 9 feet wide in the eastern field. The lengths of the rooms vary so greatly that a general statement on

[a] Report of the inspector of mines of Kentucky, 1889.

that point can not well be given. Sometimes they are driven a distance of 600 feet from one entry through to the other; again, rooms are started from parallel entries to meet midway, and will be driven up only 200 to 250 feet.

In the western field the rooms are almost invariably single. In the eastern one they are often double, or two rooms are worked from a single "parting."

It is not uncommon for rooms to be turned from the main entry, in the eastern field; in the western one it is seldom done.

In both fields single entry, with parallel air-course (rooms sometimes being turned from the air-course), is the more common of the two systems followed. Double entry is oftener followed in the western field than in the eastern. Sometimes, when single entry with parallel air-course is adopted it is ultimately modified, in order to curtail expenses, by continuing room width what began as narrow work.

In the eastern field all of the openings, with one exception, (a short slope), are drifts, considerably above the level of drainage. (And the mines there are the wettest in the State). In the western one, the coals are reached by shafts, slopes and drifts.

These methods have not changed materially except possibly in the increased number of mining machines since their introduction in 1884. In 1893, there were 70 machines in operation in the Kentucky coal mines, which produced 20 per cent of the State's output. The number of machines has gradually increased until in 1913, 1,263 mining machines produced 73.2 per cent of all of the coal mined in Kentucky.

Shooting off the solid has been and still is prevalent in Kentucky, but with the increase in the number of mining machines, there is a slight decrease in the amount of coal shot off the solid. In 1911, 16.2 per cent of the coal was thus mined and in 1913, 15.7 per cent.

A large amount of the underground haulage is by mules, which are used largely for gathering the coal from the working face and delivering it to a rope haulage or electric haulage system.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

The mine-inspection law of Kentucky was approved by the governor and became effective May 10, 1884. The law related only to mines in which more than 5 persons were employed at one time. The first State inspector was appointed May 12 and entered on duty May 14, 1884. He was required, among other things, to report to the governor not later than October 10 on the condition and operation of the coal mines and to enumerate in his report all accidents in or about the mines. The law, however, contained no provisions compelling operators to report accidents to the State inspector, and the official record of mine accidents in Kentucky from 1884 to 1888 is therefore somewhat incomplete. The defect in the original law was remedied by an act approved April 6, 1888, making it the duty, under penalty, of mine operators to furnish accurate information to the State inspector, on blanks supplied by him, as to all accidents in or about the mines.

An act approved March 23, 1914, designated the office of inspector of mines as the department of mines and changed the inspector's title to chief inspector of mines. The act applies to all coal mines in which 6 or more men are employed, and requires the superintendents of such mines to render to the chief inspector monthly reports of all fatal and serious accidents, showing the cause of such accidents, and such other information as the chief inspector may require. Fatal accidents are also required to be reported immediately to the district inspector. Each district inspector is required to examine each mine in this district at least once every four months. Monthly reports are rendered by the assistant inspectors to the chief inspector, and annual reports are rendered to the chief inspector within 60 days after the close of the calendar year. The act requires that the chief inspector shall prepare and file his annual report for printing within six months after the close of the calendar year.

The first assistant inspector was provided for by the acts of December 3, 1892, and June 9, 1893, and he entered upon his duties July 1, 1893. Since that time the inspection force has been further increased, so that in 1915 the force consisted of one chief inspector and five assistant inspectors.

It is the practice of mine operators to report to the inspector all accidents causing death or injury resulting in disability for at least 7 days, and all such accidents are published in the inspector's annual reports. Nonfatal injuries are classified into three classes: Serious, severe but not serious, and slight. The inspector has defined these classes as follows: Serious injuries include fractures, paralysis, dangerous injuries to internal organs, injuries permanently affecting muscles (as may come from burns, cuts, lacerations), dislocations, injuries necessitating amputation, crushed bones, and injuries of similar importance; severe but not serious injuries include those that, while they may be painful and cause loss of a week or more, leave no permanent effects or are not dangerous, such as bruises, cuts, and strains; slight injuries include bumps, scratches, strains and minor hurts that cause no cessation of work, or only for a few days (less than a week). Slight injuries are not recorded in the inspectors' annual reports.

ACCIDENTS.

The accompanying State tables (Nos. 103 and 104) show the total number of fatalities by causes and calendar years since 1884, as compiled from the State mine inspector's reports. They also show the percentage of accidents and fatality rates per 1,000 employed by principal causes, over a period of 26 years (1888–1913) for which continuous records are available. The fatility rate during this period is 1.98 per 1,000 men employed. There were 10 accidents in which 5 or more men

FATALITIES IN KENTUCKY COAL MINES, BY PRINCIPAL CAUSES, DURING THE YEARS 1888 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	316	49.76	0.98
Mine cars and locomotives	46	7.25	.14
Gas and dust explosions	74	11.65	.23
Explosives	89	14.02	.28
Miscellaneous	39	6.14	.12
Shaft	24	3.78	.08
Surface	47	7.40	.15
Total, 26 years	635	100.00	1.98

COAL-MINE ACCIDENTS IN KENTUCKY IN WHICH 5 OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Nature of accident.	Number killed.
1895 Jan. 22	Tate	Sturgis	Powder or mine explosion.	5
1904 Apr. 20	Stearns No. 5	Stearns	Mine explosion	5
1908 Feb. 10	Moody	South Carrollton	Blown-out shot	9
1909 Dec. 11	Baker No. 5	Clay	Mine explosion	7
1910 Feb. 1	Browder	Browder	Powder and mine explosion.	34
1910 Feb. 8	Barthell No. 1	Stearns	Mine explosion	6
1910 Nov. 25	Providence No. 3	Providence	Powder and mine explosion.	10
1912 Jan. 19	Central	Central City	Mine explosion	5
1912 Apr. 21	Coil	Madisonville	....do	5
1913 May 6	Taylor	Hartford	Overcome by gas	5

were killed at one time, or a total of 91 men, representing 14 per cent of all fatilities. The average production of coal per fatality during this period was 292,541 tons.

During recent years about one-half of the men were on a 10-hour basis; one-fourth on 9 hours, and one-fourth on 8 hours. The time element has been taken into consideration and a table compiled on

NUMBER OF HOURS TO THE WORKING DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN KENTUCKY.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, or 10 hours per day.	Total number of men employed
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	49	3,372	42	3,779	84	6,157	1,046	14,354
1904	58	3,870	60	4,208	141	5,952	205	14,235
1905	50	3,445	52	4,050	94	5,995	1,195	14,685
1906	60	4,171	65	3,972	79	5,941	1,188	15,272
1907	60	4,610	71	4,508	97	6,842	1,011	16,971
1908	56	4,636	52	2,072	132	9,166	1,122	16,996
1909[b]								16,903
1910	69	6,095	56	3,965	126	9,064	1,192	20,316
1911	79	6,102	46	4,789	144	10,289	2,943	24,124
1912	69	6,037	58	4,901	149	11,815	1,551	24,304
1913	68	5,754	84	7,389	147	12,390	799	26,332

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN KENTUCKY, AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day (all employees).	Total hours per year.	Number of 2,000-hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	207	131,971	27,317,997	13,659	27	1.98
1904	197	130,197	25,648,809	12,824	20	1.56
1905	200	134,715	26,943,000	13,472	31	2.30
1906	212	139,218	29,514,216	14,757	39	2.64
1907	210	154,971	32,543,910	16,272	32	1.97
1908	186	157,494	29,293,884	14,647	40	2.73
1909						
1910	221	185,813	41,064,673	20,533	86	4.19
1911	201	221,302	44,481,702	22,241	44	1.98
1912	201	224,514	45,127,314	22,564	51	2.26
1913	212	243,624	51,648,288	25,824	48	1.86

this basis for comparison with data on other States. The rate for the 10-year period (1903–1913) under consideration, based on the actual number of employees is 2.23 per 1,000, whereas on the number of 2,000-hours workers it is 2.36 per 1,000 (Table 40). During the 10-year period the men worked 1,885 hours per annum as compared with 2,447 hours per annum in Virginia. The tables of statistics for the State of Kentucky follow:

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN KENTUCKY.[a]

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899	837	24,598	29	1907	1,325	53,916	41
1900	2,946	90,095	31	1908	1,002	26,941	27
1901	933	32,707	35	1909	275	16,500	60
1902	1,248	22,184	18	1910	1,475	15,197	10
1903	599	13,717	22	1911	1,080	34,008	32
1904	3,781	144,245	39	1912	2,759	79,685	29
1905	923	62,651	68	1913	1,029	18,638	18
1906	1,242	44,812	36	1914	2,250	82,919	37

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 103.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN KENTUCKY, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.

[Figures for total production and all items below horizontal lines in various columns selected from Mineral Resources, U. S. Geol. Survey. Figures in column 4 and all items above horizontal lines in columns 2, 3, 8, 12, 20, and 21 from State mine inspectors' reports. Figures in columns 5, 6, and 7 and averages in columns 9 and 10 prior to 1900 calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial axe or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1828–1883	15,732,135																				
1884	1,550,000			5																	80
1885	1,600,000	$1.10	4,250	1	0.24	0.63		(a)	376												86
1886	1,550,000	1.15		1		.65		(a)													
1887	1,933,185	1.15		8		4.14		(a)													86
1888	2,570,000	1.20	6,563	14	2.13	5.45		168	392	2.33											119
1889	2,399,755	.99	5,144	12	2.33	5.00	199,980	(a)	467												
1890	2,701,496	.92	5,259	10	1.90	3.70	270,150	219	514	2.35											121
1891	2,916,069	.93	6,355	16	2.52	5.49	182,254	225	459	2.04											119
1892	3,025,313	.92	6,724	8	1.19	2.64	378,164	217	450	2.07											118
1893	3,007,179	.86	6,581	12	1.82	3.99	250,598	202	457	2.26		20.0								70	121
1894	3,111,192	.88	8,083	10	1.24	3.21	311,119	145	385	2.66											138
1895	3,357,770	.86	7,865	13	1.65	3.87	258,290	146	427	2.92		26.0								115	138
1896	3,333,478	.78	7,549	6	.79	1.80	555,580	165	442	2.68		30.0									148
1897	3,602,097	.79	7,983	12	1.50	3.33	300,174	178	451	2.53		36.1								162	133
1898	3,887,908	.79	7,614	6	.79	1.54	647,985	187	511	2.73		35.2								158	128
1899	4,607,255	.79	7,461	7	.94	1.52	658,179	224	618	2.76		35.3								189	123
1900	5,328,964	.92	9,680	17	1.76	3.19	313,468	227	551	2.43		43.9								239	124
1901	5,469,986	.95	10,307	21	2.04	3.84	260,476	213	531	2.49		41.2								237	
1902	6,766,984	.98	13,727	19	1.38	2.81	356,157	209	493	2.36		45.7								318	
1903	7,538,032	1.06	14,354	27	1.88	3.58	279,186	207	525	2.54		37.7			202	105	1			308	202
1904	7,576,482	1.04	14,235	20	1.40	2.64	378,824	197	532	2.70		47.5			336	112	5			453	
1905	8,432,523	.99	14,685	31	2.11	3.68	272,017	200	574	2.87		51.4			381	144	2			527	
1906	9,653,647	1.02	15,272	39	2.55	4.04	247,529	212	632	2.98		53.6			419	175	6			600	

1907	10,753,124	1.06	16,971	32	1.89	2.96	336,035	210	634	3.02	.....	51.2	.....	475	205	28	.....	.....	708	.....
1908	10,246,553	1.01	16,966	40	2.35	3.90	356,164	186	603	3.24	.....	51.3	.....	515	209	35	.....	.....	759	.....
1909	10,697,384	.94	16,903	34	2.01	3.18	314,639	(a)	633	(a)	.....	50.5	.....	547	310	20	.....	.....	877	267
1910	14,623,319	.99	20,316	58	4.23	5.88	170,039	221	720	3.26	.....	64.0	.....	536	325	37	1	.....	899	280
1911	14,049,703	.99	24,124	44	1.82	3.13	319,311	201	582	2.90	12.9	65.4	16.7	5.0	544	314	72	57	.....	987	306
1912	16,490,821	1.02	24,304	61	2.10	3.09	323,344	201	670	3.38	14.0	66.4	16.5	3.1	611	361	54	136	6	1,168	352
1913	19,616,600	1.05	26,332	48	1.52	2.45	408,679	212	745	3.51	9.0	73.2	15.7	2.1	674	377	98	13	1	1,263	331
Total	208,128,654	.....	.....	650	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (1883–1913)	7,144,744	.....	12,361	24.43	1.98	2.43	282,541	201	576	2.88	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	20,382,763	1.02	28,764	61	2.12	2.99	334,144	187	709	3.79	9.8	77.2	11.6	1.4	590	369	40	367	17	1,383	365

a Not reported.

TABLE 104.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN KENTUCKY, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE DURING THE CALENDAR YEARS 1884 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22				
1884	1	3				1							5													5
1885	1												1													1
1886	1												1													1
1887	3		1		2	1							7			1		1								8
1888	9		1			4							14													14
1889	9		1			2							12													12
1890	7	1				2							10													10
1891	10	1	2										13	1		1		2	1						1	16
1892	4		1										5		1			1	2						2	8
1893	9					1							10			1		1	1						1	12
1894	6		1			2							9									1			1	10
1895	4		2			[a] 6							12						1						1	13
1896	4					1							5											1	1	6
1897	5	1	2		2	1							11			1		1								12
1898	3	1				1				1			6													6
1899	4	1				1							6						1						1	7
1900	12	1	1			1							15	1		1		2								17
1901	5	2	5			4						1	17		2			2				1	1		2	21
1902	11	1				6							18						1						1	19
1903	17	1				5						2	25	1				1	1						1	27
1904	6	1	1		5	3				1			17						1					2	3	20
1905	19		2			7							28						1				2		3	31
1906	17	3	2	1		4		1					28	2	1	2		5	4					2	6	39
1907	11	1	4			7		1		1			25	3				3	1		1		2		4	32
1908	15		3		9	7		1					35		1			1	2			1	1		4	40
1909	20		2	7		2		1		1			33										1		1	34
1910	20	1	5		40	16		2				1	85						1				1		1	86
1911	28		5			4		3		1			41						1		1		1		3	44
1912	19	1	5	5	5	1		5		1			42			2		2	3				1	3	7	51
1913	24	1	1			1	[a] 5	4		2		4	42	2			1	3	1					2	3	48
1914	30		13		1	6		2		1			53	2				2	2	1	1		1	1	6	61

[a] Includes 5 fatalities at mine not under jurisdiction of inspector.

MARYLAND.

AREA AND DISTRIBUTION OF COAL FIELDS.

The coal fields of Maryland, a southward extension of those in Somerset County, Pa., occupy a strip along the western border of Allegany County about 20 miles long and averaging 5 miles in width and the greater part of Garrett County, comprising a total area of 455 square miles. The coal measures occupy broad, open, north and southwest synclinal folds, which are separated by eroded anticlines and are in the lower Carboniferous or Devonian rocks. There are five basins, known as Georges Creek, Upper Potomac, Castleman, Lower Youghiogheny, and Upper Youghiogheny. The present production of coal is almost exclusively mined from the first two basins. The prominence of the Georges Creek basin has led to the use of the name of Georges Creek coal, and until recent years practically all of this coal came from the Pittsburgh seam or "Big Vein." The coal beds are usually flat, seldom attaining a dip of 10°.

CHARACTER OF COAL BEDS.

The following description of the principal coal-producing beds of Maryland is taken from the report[a] of the Maryland Geological Survey on Allegany County for the year 1900:

The Elkgarden or "Big Vein" is more extensively developed in the Georges Creek basin, especially in the vicinity of Frostburg, than in West Virginia, where it derives its name. The "Big Vein" varies in thickness from 5 to 7 feet up to more than 20 feet, the latter thickness having, moreover, been exceeded at one or two isolated points where pockets of unusual thickness have been reached. Its usual thickness is from 10 to 12 feet, and in general it has been found to thicken southward. The coal is very clean and of the highest quality, affording a low percentage of both ash and sulphur. It is in most respects the finest steam coal known and is extensively used where the highest grade coals are demanded.

The Elkgarden coal occurs at the base of the Monongahela formation, and is probably the equivalent of the Pittsburgh vein of Pennsylvania and West Virginia, although on account of the structural conditions under which it is found it differs materially from the latter in its physical and chemical properties.

Thin, persistent bands of slate or dry partings subdivide the "Big Vein" coal into three definite members, each of which possesses special characteristics. These beds are known as Roof coal, Breast coal, and Bottom coal.

The Roof coal includes several more or less important layers of coal of varying purity and thickness, separated by thin beds of shale. Except in the northern part of the basin these roof coals are not removed in mining, since they are of particular importance as a support for the overlying strata.

The Breast coal is the thickest and the most valuable member of the "Big Vein" coal. North of Frostburg it seems to retain its purity through a thickness of scarcely more than 2 feet, while south of Lonaconing it is sometimes more than 7 feet thick and without impurities. Near the top there is a 2 to 8 inch layer of bony coal, but this is rarely sufficiently impure to necessitate its rejection. Near the bottom there is a

[a] Clark, W. B., and others, The mineral resources of Allegany County: Rept. Maryland Geol. Survey, 1900, pp. 177–178.

4 to 6 inch band of soft "mining ply," which is jet black, has a brilliant luster, and shows a strong tendency to break into small cubical blocks.

The Bottom coal is 2½ to 3 feet thick and generally contains two thin slate bands. Other impurities are sometimes present, but they are seldom of a very serious nature. On account of the slate bands the bottom coal for many years was not mined, but under an improved system of mining these thin slates are now easily removed and the coal readily taken up.

The Davis (6-foot coal bed) is one of the most important of the small-vein coals of the State. The report [a] describes it as follows:

Near Westernport, where the seam approaches 6 feet in thickness, the coal has been mined for a number of years, and although seldom put upon the market as a competitor of the "Big Vein" coal, it has nevertheless supplied a considerable part of the demand in Westernport and Piedmont and is now finding a wider market.

Throughout the lower Georges Creek Valley the Davis coal reaches a greater thickness and is more important than any other coal except the "Big Vein." This coal always contains partings of either shale or sandstone, while bone-coal is not infrequent. There is at times considerable sulphur in the lower bench. At some points in the lower Georges Creek Valley the Davis vein is quite clean and, in general, seems to improve in quality southward. The Davis vein in Allegany County generally has a roof composed of shale, overlain by heavy sandstone. The Davis coal is situated about 125–150 feet above the base of the Allegany formation. This vein is generally regarded as the approximate equivalent of the lower Kittanning coal of Pennsylvania.

The Thomas (3-foot coal) varies in thickness from 2 feet 6 inches to 3 feet 2 inches. The coal is clean and has been successfully opened north of Westernport. The bed has a characteristic shale roof and a fire-clay floor. The coal is generally regarded as the equivalent of the Upper Freeport.

MINING METHODS.

The earliest records of the production of coal in Maryland are for 1820, during which year 3,000 tons of coal was mined. The production has generally increased until in 1913, 4,779,839 tons was mined. Most of the Maryland mines are worked by the room-and-pillar method from drift entries, there being only a few slope mines. Tail-rope haulage is used to some extent, whereas mule haulage is used extensively. There are relatively few mining machines in use and these are of the pick or puncher type. In 1900 there were 10 machines in operation, producing 138,014 tons, or 3.4 per cent of the coal mined in the State. In 1904 the machine-mined coal amounted to 10 per cent of the total production. In 1913, 91.5 per cent of the coal was mined by hand, 1.7 per cent by machine, and 6.2 per cent was reported as being shot off the solid. Although the greater part of the Maryland production is mined by hand, the record of individual efficiency of the miners is high. The average production of each man in 1913 was 847 tons, or 3.42 tons for each working day.

[a] Clark, W. B., and others, op. cit., p. 173.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

An act approved March 30, 1876, authorized the governor to appoint a mine inspector for Allegany and Garrett counties whose duty it was to inspect every coal mine at least once each month. When notified by the coroner of either county, the inspector was required to attend inquests and to investigate the causes of fatal accidents at the mines. Annual reports were rendered to the governor and all mine accidents were enumerated therein. On March 24, 1902, a law was approved extending the inspection service to include clay and fire-clay mines, and directing the inspector to examine all mines as often as possible, but at least once every two months. All fatal and serious accidents in and about the mines were required to be reported to the inspector by mine operators.

It is the practice of the operators to report all accidents to the inspector, and all accidents thus reported are published in the inspector's annual reports. Injuries causing less than 7 days' disability are considered as slight.

Up to 1915 the mine inspector employed no deputy or assistant inspectors.

ACCIDENTS.

Tables 105 and 106 show the number of fatalities and men employed from the beginning of inspection service, 1876, to date, as compiled from the State mine inspectors' reports. The fatality rate for the years for which continuous records are available, 1889 to

FATALITIES IN MARYLAND COAL MINES, BY PRINCIPAL CAUSES, DURING THE YEARS 1889 TO 1913, INCLUSIVE.[a]

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	127	57.73	1.08
Mine cars and locomotives	30	13.64	.26
Gas and dust explosions			
Explosives	5	2.27	.04
Miscellaneous	36	16.36	.30
Shaft			
Surface	22	10.00	.19
Total, 23 years	220	100.00	1.87

[a] Excludes 1907 and 1908, for which the report for the fiscal year ending Apr. 30, 1908, was not available.

COAL-MINE ACCIDENTS IN MARYLAND IN WHICH 5 OR MORE MEN WERE KILLED.

Date.....1909, Jan. 25.
Name of mine.....Washington No. 5.
Location of mine.....Franklin.
Nature of accident.....Mine cars.
Number killed.....5.

1906 and 1909 to 1913, inclusive, covering 23 years, is 1.87 per 1,000 men employed. The amount of coal produced per fatality was 459,193 tons, or there were 2.18 fatalities per million tons mined. During this 23-year period 220 men were killed, of which number 57.73 per cent was due to falls of roof and 13.64 per cent to mine cars and locomotives. Maryland has been remarkably free from gas and dust explosions; the fatality rate from explosives is also low, representing only 2.27 per cent of the total number killed.

The 10-hour day prevails in Maryland and for comparison with data on 8 and 9 hour States Tables 40 and 41 have been compiled. The fatality rate for the 8-year period 1903 to 1906, and 1910 to 1913,

NUMBER OF HOURS TO THE WORKING DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN MARYLAND.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, or 10 hours per day.	Total number of men employed.
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	1	45	.....	.....	29	3,808	2,006	5,859
1904	2	72	6	974	43	4,531	94	5,671
1905	2	70	2	60	39	5,385	433	5,948
1906	.....	.....	1	50	45	6,358	30	6,438
1907	.....	.....	5	84	57	5,693	103	5,880
1908	1	80	3	59	49	5,905	35	6,079
1909[b]	.....	.....	.....	.....	.....	.....	.....	8,004
1910	3	9	6	71	61	5,717	12	5,809
1911	2	8	9	148	59	5,670	253	6,079
1912	2	53	4	41	57	6,000	68	6,162
1913	3	15	5	203	49	5,105	322	5,645

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN MARYLAND AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day (all employees).	Total hours per year.	Number of 2,000-hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	219	56,494	12,372,186	6,186	12	1.94
1904	226	55,498	12,542,548	6,271	10	1.59
1905	252	58,847	14,829,444	7,415	15	2.02
1906	250	64,300	16,075,000	8,038	6	.75
1907	263	58,613	15,415,219	7,708	.....	.....
1908	220	60,536	13,317,920	6,659	.....	.....
1909	.....	.....	.....	.....	.....	.....
1910	270	57,989	15,657,030	7,829	18	2.30
1911	243	60,373	14,670,639	7,335	15	2.05
1912	259	61,405	15,903,895	7,952	15	1.89
1913	248	55,895	13,861,960	6,931	13	1.88

inclusive, based on the actual number of employees is 2.18, whereas if reduced to the basis of 2,000-hour workers, the rate becomes 1.79. The number of hours worked per year per man in the coal mines of Maryland is 2,428, as compared with 1,620 in Michigan and 2,034 in

the bituminous mines of Pennsylvania and 2,132 in West Virginia. The tables of statistics for the State of Maryland follow:

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN MARYLAND.[a]

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899	35	420	12	1907	510	13,770	27
1900	4,787	504,544	105	1908	.....	.....	.....
1901	.....	.....	.....	1909	25	175	7
1902	.....	.....	.....	1910	.....	.....	.....
1903	120	6,045	50	1911	.....	.....	.....
1904	.....	.....	.....	1912	347	3,228	9
1905	.....	.....	.....	1913	200	400	2
1906	30	300	10	1914	91	1,547	17

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 105.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN MARYLAND, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.

[Figures for total production and all items below horizontal lines in various columns selected from Mineral Resources, U. S. Geol. Survey. Figures in column 4 and items in columns 3, 15, and 20 from State mine inspectors' reports. Figures in columns 5, 6, and 7 and averages in columns 9 and 10 prior to 1900 calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial axe or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1820–1875																					
1876	2,126,873		2,384																		
1877	1,939,575		3,000	5		2.58															
1878	2,068,925			(a)																	
1879	2,132,233		2,991	10		4.69															
1880	2,228,917			3		1.35															
1881	2,533,348		2,900	8		3.16															
1882	1,555,445			(a)																	
1883	2,476,075			8		3.23															
1884	2,765,617			(a)																	
1885	2,833,337			(a)																	
1886	2,517,577																				
1887	3,278,023			13		2.24															
1888	3,479,470			(a)																	
1889	2,939,715	$0.86	3,702	5	1.35	1.70	587,943	(a)	794												
1890	3,357,813	.86	3,842	8	2.08	2.38	419,727	244	874	3.58											
1891	3,820,239	.81	3,891	6	1.54	1.57	636,707	244	982	4.02											
1892	3,419,962	.89	3,886	6	1.54	1.75	569,994	225	880	3.91											
1893	3,716,041	.88	3,935	5	1.27	1.35	743,208	240	944	3.93											
1894	3,501,428	.77	3,974	7	1.76	2.00	500,204	215	881	4.10											
1895	3,915,585	.81	3,912	9	2.30	2.30	435,065	248	1,001	4.04											
1896	4,143,936	.80	4,039	6	1.49	1.45	690,656	204	1,026	5.03											
1897	4,442,128	.76	4,719	5	1.06	1.13	888,426	262	941	3.59											
1898	4,674,884	.76	4,818	4	.83	.86	1,168,721	253	970	3.83											
1899	4,807,396	.76	4,624	5	1.08	1.04	961,479	275	1,040	3.78		0.3			8					8	
1900	4,024,688	.98	5,319	7	1.32	1.74	574,955	203	757	3.73		3.4			10					10	

| | | |

TABLE 106.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN MARYLAND, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE, DURING THE CALENDAR YEARS 1877 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions including gas and dust combined.	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1876																										
1877	3	1	1										5													5
1878 [a]																										
1879	4	4	2										10													10
1880	1	1	1										3													3
1881	5		3										8													8
1882 [a]																										
1883	6		1			1							8													8
1884 [a]																										
1885 [a]																										
1886	7	3	3										13													13
1887																										
1888 [a]																										
1889	5												5													5
1890	4	1	3										8													8
1891 [a]												6	6													6
1892	3	1	1						1				6													6
1893	2	2	1										5													5
1894	5	1	1										7													7
1895	2		3									1	6						2		1				3	9
1896												6	6													6
1897	3	1										1	5													5
1898	3	1											4													4
1899	2	2											4						1						1	5
1900												7	7													7
1901												12	12													12
1902	3	4	3										10						1						1	11
1903	4	1	5										10						1				1		2	12
1904	7	1				1							9											1	1	10

| | | |

MICHIGAN.

AREA AND DISTRIBUTION OF COAL FIELDS.

The coal-bearing area of Michigan comprises about 11,000 square miles and occupies a basin in the central part of the lower peninsula between Lake Huron and Lake Michigan. The field extends from Jackson County on the south to Roscommon County on the north and from Tuscola County on the east to Kent County on the west. The principal mining operations are in Bay and Saginaw Counties in the northeastern part of the field.

CHARACTER OF COAL BEDS.

The structure of the field is a comparatively flat basin modified by minor undulations. There are at least seven coal-bearing horizons in which coal may be considered as workable at certain places. The three principal coal beds are the Upper and Lower Verne and the Saginaw. The Upper and Lower Verne beds usually are close together and in a number of places are mined as one bed of coal. These beds vary in thickness from place to place, but the thickness of a single bed is not generally more than 3 feet. The combined thickness of the two beds within 10 feet of strata may be 7 feet. These coal beds are more or less undulating and in one instance a rise of 22 feet within 150 feet without faulting has been noted. In consequence of this irregularity many of the working plans of the mines in which the workings follow troughs are very irregular, and as most of the merchantable coal is less than 4 feet, some being less than 2 feet thick, large areas of this coal are left untouched. They are 100 to 150 feet below the surface. The Saginaw bed is somewhat deeper.

MINING METHODS.

The records for coal production for Michigan began in 1860, when 2,320 tons of coal were mined. The production in 1913 was 1,231,786 tons. Practically all of the mines are opened by shafts 100 to 150 feet deep. The room-and-pillar system of mining is the principal method in use. The longwall method was tried at one or two mines but it was abandoned for the reason that there was too much danger of shattering the roof and letting in water from the glacial overburden. Mining machines were first introduced in Michigan in the Bay City district and became an important feature in Michigan mines in 1899, when 25 machines produced slightly over 10 per cent of the coal. In 1913, 70 per cent of the coal was produced by machines and 29.5 per cent shot off the solid.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

The legislature of Michigan, by an act approved May 2, 1899, authorized the commissioner of labor to appoint an inspector of coal mines, the inspector to examine all coal mines in the State and to report, from time to time, the results of his examinations to the commissioner of labor. The results of the inspector's examinations were incorporated in the regular annual report of the commissioner. The inspector was authorized to enter any coal mine at any time for the purpose of inspection or to collect statistics relating to "hours of labor, wages, industrial, economic and sanitary questions or matters, scales and oils." It was specified in an act approved May 10, 1905, that the law applied to "any shaft in process of sinking, and any opening projected for the purpose of mining coal." On June 2, 1909, a law was approved directing the commissioner of labor, under whose supervision the inspection of coal mines was carried on, to include in his annual reports beginning April 1, 1910, a statement showing the number of persons employed and the number and character of accidents in all departments of labor in the State.

All mine accidents are reported to the inspector and are published in his annual report to the commissioner of labor. Serious and slight injuries are neither segregated nor defined.

In 1915 the inspector employed no assistants.

ACCIDENTS.

Tables 107 and 108 show the total number of fatalities by calendar years and causes from 1899 to 1913, inclusive, as compiled from the State mine inspector's reports. Beginning with 1900 to and including 1913, for which continuous records are available, 98 men were killed,

FATALITIES IN MICHIGAN COAL MINES, BY PRINCIPAL CAUSES, DURING THE YEARS 1900 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	51	52.04	1.13
Mine cars and locomotives	2	2.04	.04
Gas and dust explosions	0	.....	.....
Explosives	15	15.31	.33
Miscellaneous	15	15.31	.33
Shaft	10	10.20	.22
Surface	5	5.10	.11
Total, 14 years	98	100.00	2.16

representing a fatality rate of 2.16 per 1,000 men employed. Of the total number of fatalities 52.04 per cent was due to falls of roof-and-

pillar coal, 15.31 per cent to explosives, and 10.20 per cent to shaft accidents. Michigan has been fortunate in the matter of mine disasters, none having occurred in which 5 or more men were killed at one time. No fatalities are reported as due to gas and dust explosions. The average production per fatality during the 14-year period above referred to was 200,919 tons, or 4.98 fatalities per million tons mined.

Since 1905 practically all of the men employed in and about the mines of Michigan have been on an 8-hour basis. This, to a certain extent, accounts for the low fatality rate compared with other States, in which the men are employed 9 or 10 hours. The average number of hours worked per year per man in Michigan was 1,620

NUMBER OF HOURS TO THE WORKING DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN MICHIGAN.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, or 10 hours per day.	Total number of men employed
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	9	1,233	.....	.....	.....	.....	1,535	2,768
1904	20	2,627	.....	.....	.....	.....	922	3,549
1905	23	3,327	.....	.....	.....	.....	369	3,696
1906	27	3,941	.....	.....	.....	.....	30	3,971
1907	27	3,939	.....	.....	.....	.....	43	3,982
1908	31	4,224	.....	.....	.....	.....	23	4,247
1909[b]	.....	.....	.....	.....	.....	.....	.....	3,696
1910	27	3,511	.....	.....	.....	.....	64	3,575
1911	21	3,199	.....	.....	.....	.....	49	3,248
1912	20	3,107	.....	.....	.....	.....	6	3,113
1913	24	3,305	.....	.....	.....	.....	.....	3,305

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN MICHIGAN AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day (all employees).	Total hours per year.	Number of 2,000 hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	222	23,679	5,256,738	2,629	8	3.04
1904	183	29,314	5,364,462	2,682	6	2.24
1905	186	29,937	5,568,282	2,784	9	3.23
1906	173	31,798	5,501,054	2,751	5	1.82
1907	234	31,899	7,464,366	3,732	7	1.88
1908	207	33,999	7,037,793	3,519	6	1.71
1909	.....	.....	.....	.....	.....	.....
1910	211	28,664	6,048,104	3,024	6	1.98
1911	218	26,033	5,675,194	2,838	7	2.47
1912	183	24,910	4,558,530	2,280	8	3.51
1913	188	26,440	4,970,720	2,486	3	1.21

during the 10-year period, 1903–1913, as compared with 2,172 in Colorado or 2,034 in Pennsylvania (bituminous) and 2,447 in Virginia. The fatality rate (Table 40) based on the actual number of

men employed, is 1.83 for the 10-year period, as compared with 2.26 based on the 2,000-hour workers. Table 41 shows the fatality rates for a period of 10 years based on the 2,000-hour year for all the States, so that by referring to this table a true comparison of Michigan with other States may be seen. The tables of statistics for the State of Michigan follow:

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN MICHIGAN.[a]

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899	487	9,547	20	1907	265	1,325	5
1900	81	1,514	19	1908	300	4,800	16
1901	.....	.....	.....	1909	527	23,002	44
1902	1,935	239,146	124	1910	1,663	86,789	52
1903	75	825	11	1911	.....	.....	.....
1904	564	2,402	4	1912	2,028	101,424	50
1905	.....	.....	.....	1913	180	1,260	7
1906	3,340	294,630	88	1914	.....	.....	.....

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 107.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN MICHIGAN, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.

[Figures for total production and all items below horizontal lines in various columns selected from Mineral Resources, U. S. Geol. Survey. Figures in column 4 and items above horizontal line in column 2 from State mine inspectors' report. Figures in columns 5, 6, and 7 and averages in columns 9 and 10 prior to 1900 calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial axe or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1860–1888	1,435,711																				
1889	67,431	$1.71	261					(a)	258												
1890	74,977	1.99	180					229	417	1.82											
1891	80,307	1.66	223					205	360	1.76											
1892	77,990	1.56	230					195	339	1.74											
1893	45,979	1.79	162					154	284	1.84											
1894	70,022	1.47	223					224	314	1.40											
1895	112,322	1.60	320					186	351	1.89											
1896	92,882	1.62	320					157	290	1.85											
1897	223,592	1.46	537					230	416	1.81											
1898	315,722	1.47	715					245	442	1.80		0.5								7	
1899	624,708	1.39	1,291	4				232	484	2.09		10.2			17	8				25	
1900	849,475	1.48	1,704	10	5.87	11.77	84,948	261	499	1.91		22.6								33	
1901	1,241,241	1.41	2,276	6	2.64	4.83	206,874	247	545	2.21		14.3								31	
1902	964,718	1.71	2,344	8	3.41	8.29	120,590	171	412	2.41		20.3								58	
1903	1,367,619	1.97	2,768	8	2.89	5.85	170,952	222	494	2.23		13.2			46					46	
1904	1,342,840	1.81	3,549	6	1.69	4.47	223,807	183	378	2.07		23.1			84	1				85	
1905	1,473,211	1.71	3,696	9	2.44	6.11	163,690	186	399	2.15		29.3			90	16				106	
1906	1,346,338	1.80	3,971	5	1.26	3.71	269,268	173	339	1.96		31.0			88	22				110	
1907	2,035,858	1.80	3,982	7	1.76	3.44	290,837	234	511	2.18		29.8			60	42	1			103	
1908	1,835,019	1.81	4,247	6	1.41	3.27	305,837	207	432	2.09		29.2			85	33	2			120	
1909	1,784,692	1.79	3,496	9	2.57	5.04	198,299	(a)	510	(a)		28.7			66	34	1			101	32
1910	1,534,967	1.91	3,575	6	1.68	3.91	255,828	211	429	2.03		45.5			51	42	4	3		100	32
1911	1,476,074	1.89	3,248	7	2.16	4.74	210,868	218	454	2.08	10.7	49.8	37.2	2.3	60	46		7		113	26

1912	1,206,230	1.99	3,113	8	2.57	6.63	150,779	183	387	2.11	10.0	52.7	36.7	.6	48	37	.....	41	.....	126	22
1913	1,231,786	1.99	3,305	3	.91	2.44	410,595	188	373	1.98	.2	70.0	29.5	.3	26	38	.....	66	.....	130	26
Total	22,911,711	.....	.....	102	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (1900–1913)	1,406,433	.....	3,234	7	2.16	4.98	200,919	204	425	2.13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	1,283,030	2.00	2,800	2	.71	1.56	641,515	201	458	2.28	.2	77.8	21.9	.1	17	18	.....	72	.....	107	19

[a] Not reported.

TABLE 108.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN MICHIGAN, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE DURING THE CALENDAR YEARS 1899 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1899 [a]	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
1900	6	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	8	.....	.....	1	.....	1	.....	.....	.....	.....	.....	1	1	10
1901	2	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
1902	5	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	6	.....	.....	2	.....	2	.....	.....	.....	.....	.....	.....	.....	8
1903	2	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	4	1	.....	.....	.....	1	.....	.....	.....	2	.....	1	3	8
1904 [b]	3	1	.....	.....	.....	1	.....	.....	.....	.....	.....	1	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
1905	5	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	3	9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9
1906	1	1	.....	.....	.....	.....	.....	1	.....	.....	.....	1	4	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	5
1907	2	.....	1	.....	.....	2	.....	.....	.....	.....	.....	1	6	.....	1	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	7
1908	4	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	5	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	6
1909	5	.....	.....	.....	.....	1	.....	1	.....	.....	.....	1	8	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	9
1910	4	.....	1	.....	.....	1	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
1911	3	1	.....	.....	.....	.....	.....	2	.....	.....	.....	1	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7
1912	4	.....	.....	.....	.....	.....	.....	1	.....	1	.....	.....	6	.....	1	.....	.....	1	.....	.....	.....	.....	1	.....	1	8
1913	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	3
1914	1	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2

[a] June 1 to Dec. 1.

[b] Causes of fatalities, 1904 to 1909, inclusive, not given in official reports. Classification here given based on description of each individual accident as published in local newspapers. The totals are from inspectors' reports.

MISSOURI.

AREA AND DISTRIBUTION OF COAL FIELDS.

The productive coal area of Missouri comprises much of the northern half of the State, and a strip on the western border. It extends north into Iowa and west into Kansas. As in Iowa, the terms Des Moines and Missouri groups are applied to the upper and lower coal-bearing measures, respectively, both of which are in the Pennsylvanian series of the Carboniferous system. The Des Moines, which includes nearly all the coal beds of present economic importance, outcrops in about 16,000 square miles and also underlies the Missouri group in about 8,000 square miles.

CHARACTER OF COAL BEDS.

In the north-central part of the State the coal beds are horizontal; in the western and northwestern part they dip northwest about 8 feet per mile.

The Missouri coal is low-grade bituminous, and more than 90 per cent is produced from the Des Moines group. The Bevier field in the north-central part of the State produces about 30 per cent of the coal from a bed varying 3 feet to 6 feet in thickness. The roof is sandy shale and sandstone of only moderate stability. The bed in the Lexington field is 14 to 26 inches thick and produces 25 to 30 per cent of the coal. The roof is a black, slaty shale with a strong limestone cap rock and is almost ideal for longwall mining.

The Southwestern field includes Henry, Barton, and Bates counties and produces about 20 per cent of the coal from a coal bed 3 to 4 feet thick. In these counties there are a few open-pit mines. The Novinger field (Adair County) produces about 10 per cent of the coal from a bed that is about 3½ feet thick. There are several smaller fields in other parts of the State.

MINING METHODS.

The earliest statistics of coal production for Missouri date back to 1840, when 9,972 tons of coal were produced. The production for 1913 was 4,318,125 tons.

In 1912 there were about 214 mines in operation of which 136 were opened by shaft, 36 by slope, 25 by drift, and 7 were strip pits. Of this number 102 used the longwall method, and 94 the room-and-pillar method of mining. The longwall method is used almost exclusively in the Lexington field, where the coal is thin and has a good roof. In the other fields various forms of room and pillar methods are used. Electric haulage is used in 13 mines; mule haulage in 94, and hand haulage in 41 mines. Fifty-eight mines were ventilated by natural draft, 52 by furnaces, and 88 by fans. Hoisting at 80 mines was by steam power, at 3 by electricity, at 64 by horsepower, and at 5 by hand power.

Mining machines have been used in Missouri since 1896, when 4 machines were operated, producing 2.6 per cent of the coal. The number of machines has gradually increased until in 1913 there were 104 machines producing 20 per cent of the coal. It is reported that 46.8 per cent is shot off the solid, and 23.6 per cent is mined by hand.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

The first mine-inspection service of Missouri was provided for by the act approved March 23, 1881, authorizing the court of every county where coal mines were situated to appoint a county mine inspector. It was made the duty of mine operators to report to the inspector, under penalty, all fatal and serious accidents at their mines, and, if the accident was fatal, it was to be reported to the county coroner, or, in his absence or inability to act, to any justice of the peace in the county. If deemed necessary from the facts reported, the inspector was required to go to the scene of the accident, render assistance, investigate the cause of the accident, and preserve a record of his investigation with the other records of his office. The county inspectors rendered annual reports to the "Commissioner of Labor Statistics," showing causes of accidents, number employed in and about the mines, etc.

The law of March 30, 1887, consolidated the inspection service under the jurisdiction of a State mine inspector appointed by the governor on the recommendation of a board of examiners. The inspector thus appointed rendered annual reports on October 15 to the bureau of labor statistics.

The act of April 26, 1899, created a bureau of mines, mining, and mine inspection, and authorized the appointment of two mine inspectors—one for coal mines and the other for lead and zinc mines—the inspectors being given authority to appoint a secretary. The act of March 27, 1901, required the inspector to report to the governor by April 15 of each year. An assistant inspector was authorized by the act of March 30, 1907. The coal-mine inspection force was increased by the act of March 25, 1913, which authorized the appointment of a chief inspector and two assistants inspectors, the chief inspector to render annual reports to the governor on January 1 in accordance with existing laws.

It has not been definitely determined in Missouri when an injury is sufficiently serious to come within the requirement of the law that it shall be reported to the inspector, but it is the practice of the operators to report all injuries causing three or four days' disability, and these are published in the inspector's annual reports. Of the injuries reported to the inspector, those resulting in disability of an employee for at least 30 days are classified as serious, all others being considered slight injuries.

ACCIDENTS.

The number of accidents in the coal mines of Missouri, by causes and calendar years, is contained in Tables 109 and 110. These tables also show the total number and percentage of fatalities classified by principal causes, and the fatality rate per 1,000 men employed for a period of 26 years (1888–1913), for which continuous records are

FATALITIES IN MISSOURI COAL MINES, BY PRINCIPAL CAUSES, DURING THE YEARS 1888 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	235	62.17	1.10
Mine cars and locomotives	19	5.03	.09
Gas and dust explosions	40	10.58	.19
Explosives	43	11.38	.20
Miscellaneous	10	2.64	.05
Shaft	27	7.14	.13
Surface	4	1.06	.02
Total, 26 years	378	100.00	1.78

COAL-MINE ACCIDENTS IN MISSOURI IN WHICH 5 OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Nature of accident.	Number killed.
1888 Mar. 29	Keith and Perry No. 6.	Rich Hill	Mine explosion	24
1915 Feb. 18	Atlas	do	do	5

available. The fatality rate during this period is 1.78 per 1,000 men employed. During the 26 years there was only one serious mine disaster, in which more than 5 men were killed at one time. This was a mine explosion in 1888 in which 24 men were killed, representing slightly over 6 per cent of the total number of fatalities during the period covered. Falls of roof and pillar coal are responsible for 62.17 per cent; gas and dust explosions, 10.58 per cent; and explosives, 11.38 per cent. The average production of coal per fatality was 229,541, or there were 4.36 fatalities per million tons of coal mined.

About 97 per cent of the men employed in the coal mines of Missouri since 1903 have been eight-hour men. As there are a number of States in which men are employed 9 or 10 hours per day, the time element has been taken into consideration, and tables compiled on this basis for comparison with other States. The fatality rate for the 10-year period 1903–1913 (Table 40), based on the actual number of men employed, is 1.30 per 1,000, and on the number of 2,000-hour workers is 1.70. During the 10-year period the men averaged 1,539 hours per year as compared with 2,463 hours in New Mexico, 2,132

NUMBER OF HOURS TO THE WORKING-DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN MISSOURI.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, or 10 hours per day.	Total number of men employed.
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	191	9,119	8	51	7	52	322	9,544
1904	198	9,686	10	72	8	65	314	10,137
1905	194	8,096	6	70	4	25	771	8,962
1906	134	8,645	6	58	6	80	774	9,557
1907	149	8,079	6	54	.....	.....	315	8,448
1908	149	8,464	10	83	.....	.....	441	8,988
1909[b]	.....	.....	.....	.....	.....	.....	.....	9,188
1910	166	9,027	10	100	1	17	547	9,691
1911	193	9,523	8	84	.....	.....	.....	9,607
1912	172	9,139	5	72	3	17	476	9,704
1913	179	10,200	4	79	.....	.....	139	10,418

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN MISSOURI AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day (all employees).	Total hours per year.	Number of 2,000-hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	215	76,829	16,518,235	8,259	17	2.06
1904	206	81,612	16,812,072	8,406	11	1.31
1905	194	72,587	14,081,878	7,041	11	1.56
1906	185	77,448	14,327,880	7,164	16	2.23
1907	214	67,953	14,541,942	7,271	8	1.10
1908	169	72,428	12,240,332	6,120	10	1.63
1909	.....	.....	.....	.....	.....	.....
1910	154	78,209	12,044,186	6,022	14	2.32
1911	152	76,940	14,003,080	7,002	8	1.14
1912	206	78,214	16,112,084	8,056	19	2.36
1913	187	83,562	15,626,094	7,813	10	1.28

in West Virginia, and 1,704 in Iowa. Table 41 shows the fatality rate for each year on the 2,000-hour basis for each State, so that a true comparison of Missouri with other States may be easily made. The tables of statistics for the State of Missouri follow:

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN MISSOURI.[a]

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899	2,197	117,076	53	1907	777	8,222	11
1900	632	34,970	55	1908	6,350	355,138	56
1901	1,042	31,318	30	1909	957	6,593	7
1902	1,364	61,273	45	1910	7,774	1,218,599	157
1903	1,306	13,892	11	1911	504	24,216	48
1904	1,844	26,312	14	1912	952	55,022	58
1905	435	6,788	16	1913	918	31,251	34
1906	6,212	483,790	78	1914	1,162	56,536	49

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 109.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN MISSOURI, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.

[Figures for total production and all items below horizontal lines in various columns selected from Mineral Resources, U. S. Geol. Survey. Figures in column 4 compiled from State mine inspectors' reports. Figures in columns 5, 6, and 7 and averages in columns 9 and 10 prior to 1900 calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Longwall.	Shortwall.	Radial axe or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1840–1886	30,191,886																				
1887	3,209,916		7,000						458												
1888	3,909,967		8,800	27	3.07	6.91	144,814		444												
1889	2,557,823	$1.36	6,631	10	1.51	3.91	255,782	(a)	386												
1890	2,735,221	1.24	5,971	18	3.01	6.58	151,957	229	458	2.00											
1891	2,674,606	1.23	6,199	20	3.23	7.48	133,730	218	431	1.98											
1892	2,733,949	1.23	5,893	22	3.73	8.05	124,270	230	464	2.02											
1893	2,897,442	1.23	7,375	18	2.44	6.21	160,969	206	393	1.91											
1894	2,245,039	1.17	7,523	19	2.53	8.46	118,160	138	298	2.16											
1895	2,372,393	1.12	6,299	13	2.06	5.48	182,492	163	377	2.31											
1896	2,331,542	1.08	5,982	8	1.34	3.43	291,443	168	390	2.32		2.6								4	
1897	2,665,626	1.08	6,414	12	1.87	4.50	222,136	191	416	2.18		2.2								3	
1898	2,688,321	1.07	6,542	10	1.53	3.72	268,832	198	411	2.07		2.0								4	
1899	3,025,814	1.20	7,136	11	1.54	3.64	275,074	212	424	2.00		1.8			1		8			9	
1900	3,540,103	1.21	8,180	19	2.32	5.37	186,321	214	433	2.02		3.1								15	
1901	3,802,088	1.24	9,871	16	1.62	4.21	237,631	223	385	1.73		4.0								24	
1902	3,890,154	1.38	9,739	10	1.03	2.57	389,015	202	399	1.98		5.8								20	
1903	4,238,586	1.61	9,544	17	1.78	4.01	249,329	215	444	2.07		7.4			4		29			33	
1904	4,168,308	1.63	10,137	11	1.09	2.64	378,937	206	411	2.00		9.0				1	30			31	
1905	3,983,378	1.58	8,962	11	1.23	2.76	362,125	194	444	2.29		9.4				2	28			30	
1906	3,758,008	1.63	9,557	16	1.67	4.26	234,876	185	393	2.12		11.2			4		44			48	
1907	3,997,936	1.64	8,448	8	.95	2.00	499,742	214	473	2.21		12.2			4	4	54			62	
1908	3,317,315	1.64	8,988	10	1.11	3.01	331,732	169	369	2.18		14.5			5	52				57	

1909	3,759,530	1.65	9,188	21	2.29	5.59	178,893	(a) 154	459	(a) 2.00	.....	21.2	.....	.....	4	18	74	.....	96	224
1910	2,982,453	1.70	9,661	14	1.44	4.69	213,081		308			18.6	.....	.....	23	.....	73	.....	96	208
1911	3,836,107	1.72	9,607	8	.83	2.09	479,513	152	399	2.19	19.9	19.6	49.4	11.1	17	.....	75	.....	92	232
1912	4,339,356	1.76	9,704	19	1.96	4.38	228,413	206	447	2.17	23.9	20.7	48.0	7.4	2	2	78	4	86	217
1913	4,318,125	1.73	10,413	10	.96	2.32	431,813	197	414	2.21	23.6	20.0	46.8	9.6	7	7	80	10	104	208
Total	120,168,472	.....	.....	378	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (1886–1913)	3,387,180	.....	8,185	14.54	1.78	4.36	229,541	195	406	2.09	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	3,835,960	1.73	9,549	19	1.99	4.83	207,157	179	412	2.30	22.2	19.0	45.6	12.2	2	1	79	6	88	178

a Not reported.

TABLE 110.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN MISSOURI, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE DURING THE CALENDAR YEARS 1887 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1888 [a]					24							3	27													27
1889 [a]	6	1	1			1							9			1		1								10
1890 [b]	10			1		4							15	1		1		2	1						1	18
1891	10	2	1			3	1						17			3		3								20
1892	12	2	1	3		2							20			1		1								21
1893	13	1	1			1							16	1		1		2						1	1	19
1894	10	1		4		1	1						17	1				1			1				1	19
1895	6		1			5							12			1		1								13
1896	7												7			1		1								8
1897	7	1	1			1							10			2		2								12
1898	6	1	1			1							9	1				1								10
1899	8		1		2								11													11
1900	16		1			1							18			1		1								19
1901	10		1			5							16													16
1902	5	1	1			1							8	1		1		2								10
1903	10		1	3		3							17													17
1904	8					3							11													11
1905	7	1				2							10	1				1								11
1906	12					2							14	1	1			2								16
1907	6		1			1							8													8
1908	8	1	1										10													10
1909	10	4				4							18	1		2		3								21
1910	8		3			1						2	14													14
1911	6	1											7										1		1	8
1912	7	2	2	2	1			2					16	1		2		3								19
1913	8					1						1	10													10
1914	12		2										14			5		5								19

[a] Fiscal year ending Oct. 15.

[b] Includes Oct. 15 to Dec. 31, 1889, making 14½ months.

MONTANA.

AREA AND DISTRIBUTION OF COAL FIELDS.

The coal fields of Montana are widely distributed over the eastern two-thirds of the State, and have an aggregate area of about 39,000 square miles. From a commercial standpoint there are only three important fields in the State. These are, according to production, as follows: (1) Red Lodge field in Carbon County, (2) Bull Mountain field in Musselshell County, and (3) the Great Falls field in Cascade County.

The Red Lodge field comprises an area of about 50 square miles, but the number and thickness of the beds compensate in large measure for the small size of the field. The beds dip to the southwest toward the Beartooth Mountain, from which they are separated by a great fault.

The Bull Mountain field has a known productive area of 630 square miles, being a great synclinal basin lying mainly between Yellowstone and Musselshell rivers. This field has developed since the building of the Chicago, Milwaukee & St. Paul Railway in 1908.

The Great Falls coal field, which contains about 1,500 square miles, is south and east of the town of Great Falls. This field is one of the first to be developed in the State, but owing to the heavy percentage of ash the coal can hardly compete with that from Red Lodge and Bull Mountain.

The Milk River field, in the northern part of the State, as well as the great lignite fields in the eastern part, cover large areas, but are only slightly developed.

CHARACTER OF COAL BEDS.

The coal beds of the Red Lodge field vary from 3 to 12 feet in thickness; the coal is high-grade subbituminous, slacks readily, and for this reason pillars will soon crush when left standing, and thus allow the roof to fall. The coal about Bridger, a little to the northeast of Red Lodge, is bituminous, but only a little of this coal is mined at present.

In the Bull Mountain field the coal beds occupy a synclinal trough. There are 10 to 16 feet of clean coal; the dip does not exceed 6°. The mines are opened by shafts ranging from 137 to 350 feet deep. The quality of the coal is about the same as that mined in the Red Lodge field.

In the Great Falls field the beds are 3 to 7½ feet thick, with a slight dip to the north. At Sand Coulee, the principal mining center of this field, the beds are flat and about 10 feet thick. The coal is bituminous and intrinsically of higher grade than from either of

the fields so far described, but the heavy percentage of ash detracts greatly from its commercial value, and the field, which up to 1907 held first place in the State's production, has now dropped to third place.

In the Milk River field the roof in most cases is a soft sandstone or carbonaceous shale, making it necessary to leave considerable coal to keep the entries from caving in. Extensive timbering will be necessary when mining is done on a large scale.

MINING METHODS.

The mines at Chestnut, Gallatin County, are the oldest in the State, having been opened in 1867, and coal hauled from them long distances by teams. The records show that the production of coal in Montana began in 1880, when 224 tons were reported as mined. In 1913 the production was 3,240,973 tons, of which Carbon County mined 1,187,270 tons. The mines are opened by drift, slope, and shaft, and are mined by the room-and-pillar and pillar-and-stall systems. At Stockett the roof is sandstone, and the coal is mined by machines. Machines are also extensively used at Belt. In 1896 there were 62 mining machines in use in the State, which produced 37.5 per cent of the coal; in 1913 there were 97 machines, producing 33.2 per cent of the coal, whereas 35 per cent was shot off the solid, and 31 per cent was reported as being mined by hand.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

The first mine-inspection law of Montana was approved March 14, 1889, and provided for the inspection of all mines where 5 or more men were employed, except mines operated only by the owners or lessees. The inspector was authorized to employ an assistant to act in cases of emergency, as in cases of accidents, or in the absence of the inspector. The assistant's salary was on a per diem basis and his employment was limited to 100 days a year. Mine operators were required to report to the inspector or his deputy all fatal and serious accidents in and about the mines. The inspector was required, whenever possible, to go to the scene of the accident and investigate the cause thereof; and if it was not possible for the inspector to visit the mine, the person in charge was required to obtain written and sworn statements from persons who had witnessed the accident. The inspector rendered annual reports to the governor and enumerated therein all accidents of which he had received notice.

On March 4, 1897, an act was approved directing the deputy inspector to devote his entire time to his official duties. On March 18, 1901, an act relating exclusively to coal mines was approved, and

the governor was authorized to appoint a coal-mine inspector. An act approved March 4, 1913, created a department of labor and industry, consisting of a commissioner, boiler inspector, inspector of mines, and coal-mine inspector, and directed that the annual reports of these inspectors should be combined in one volume and published biennially. The authority to appoint the deputy inspector was transferred from the coal-mine inspector to the governor by an act approved March 31, 1913.

Mine operators in Montana report to the inspector only those accidents causing at least 14 days' disability, and these are published in the inspector's annual reports. Accidents causing disability for less than 14 days are not considered serious.

ACCIDENTS.

Tables 111 and 112 show the number of fatalities in and about the coal mines in Montana, classified by causes and calendar years since 1889, as compiled from the State mine inspector's reports. The years 1896 and 1899 are left blank, as reports for these years were not available. Continuous records for 1900 to 1913, inclusive, show that 159 men were killed in and about the coal mines in Montana,

FATALITIES IN MONTANA COAL MINES, BY PRINCIPAL CAUSES, DURING THE YEARS 1900 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	88	55.34	2.15
Mine cars and locomotives	23	14.47	.56
Gas and dust explosions			
Explosives	11	6.92	.27
Miscellaneous	27	16.98	.66
Shaft	1	.63	.02
Surface	9	5.66	.23
Total, 14 years	159	100.00	3.89

COAL-MINE ACCIDENTS IN MONTANA IN WHICH 5 OR MORE MEN WERE KILLED

Date.	Name of mine.	Location of mine.	Nature of accident.	Number killed.
1906 June 7	Red Lodge	Red Lodge	Mine fire	8
1908 Nov. 20	do	do	do	9

representing a fatality rate of 3.89 per 1,000 men employed. Of this number 55.34 per cent were killed by falls of roof and pillar coal and 14.47 by mine cars and locomotives. Montana has been free from disasters due to gas and dust explosions. The production per fatality was 186,276, or there were 5.37 fatalities per million tons of coal

mined. There have been two mine fires, in which 17 men were killed.

The 8-hour day prevails in Montana and the time element is, therefore, taken into consideration for comparison with other 8-hour and with 10-hour States (Table 40). The total number of hours worked per year is 1,930, as compared with 2,447 for Virginia or

NUMBER OF HOURS TO THE WORKING DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN MONTANA.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, or 10 hours per day.	Total number of men employed.
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	13	449	5	1,635	1	3	68	2,155
1904	19	646	8	1,653	4	12	194	2,505
1905	23	[b] 1,707	.....	.....	2	6	468	2,181
1906	28	[b] 2,203	1	85	.....	.....	106	2,394
1907	29	2,732	1	3	.....	.....	.....	2,735
1908	36	2,903	1	2	.....	.....	241	3,146
1909 [c]	.....	.....	.....	.....	.....	.....	.....	4,535
1910	44	3,568	.....	.....	1	6	263	3,837
1911	44	3,862	.....	.....	.....	.....	2	3,864
1912	39	3,435	.....	.....	1	5	.....	3,440
1913	40	3,416	1	4	.....	.....	210	3,630

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.
[b] Including day men who work 10 hours.
[c] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN MONTANA AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day (all employees).	Total hours per year.	Number of 2,000-hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	254	18,949	4,813,046	2,407	5	2.08
1904	243	21,911	5,324,373	2,662	9	3.38
1905	243	17,928	4,356,504	2,178	8	3.67
1906	243	19,343	4,700,349	2,350	13	5.53
1907	268	21,883	5,864,644	2,932	13	4.43
1908	224	25,411	5,692,064	2,846	21	7.38
1909	.....	.....	.....	.....	.....	.....
1910	239	30,971	7,402,069	3,701	12	3.24
1911	220	30,914	6,801,080	3,401	14	4.12
1912	220	27,530	6,056,600	3,028	7	2.31
1913	228	29,254	6,669,912	3,335	20	6.00

2,255 for Alabama. The total number of hours of labor performed has been converted to a 2,000-hour basis and fatality rates shown in Table 41, for comparison with other States. The fatality rate on the actual number of men employed during the 10-year period 1903 to 1913 (except 1909) is 4.08, as compared with 4.23 fatalities per 1,000 on the basis of 2,000-hour workers. The tables of statistics for the State of Montana follow:

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN MONTANA.[a]

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899	650	33,800	52	1907	30	600	20
1900	40	1,640	41	1908	556	9,201	17
1901	285	14,175	49	1909	110	1,110	10
1902	686	7,636	11	1910	345	38,260	111
1903	.....	.....	.....	1911	529	8,114	15
1904	792	37,140	47	1912	869	8,445	10
1905	200	36,000	180	1913	1,094	6,682	6
1906	2.0	7,0.0	31	1914	171	1,271	7

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 111.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN MONTANA, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.

[Figures for total production and all items below horizontal lines in various columns selected from Mineral Resources, U. S. Geol. Survey. Figures in column 4 compiled from State mine inspectors' reports. Figures in columns 5, 6, and 7, and averages in columns 9 and 10 prior to 1900 calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial axe or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1880–88	303,350	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1889	363,301	$2.42	848	0	.....	.....	.....	(a)	428	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1890	517,477	2.42	1,251	1	0.80	1.93	517,477	218	414	1.90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1891	541,861	2.27	1,119	7	6.26	12.92	77,409	(a)	484	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1892	564,648	2.36	1,158	3	2.59	5.31	188,216	258	488	1.89	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1893	892,309	1.99	1,401	1	.71	1.12	892,309	242	637	2.63	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1894	927,395	2.04	1,782	6	3.37	6.47	154,566	192	520	2.71	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1895	1,504,193	1.89	2,184	b 8	.....	.....	.....	223	689	3.09	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1896	1,543,445	1.47	2,335	(a)	.....	.....	.....	234	661	2.82	.....	37.5	.....	.....	.....	.....	.....	.....	.....	62	.....
1897	1,647,882	1.76	2,337	11	4.71	6.68	149,807	252	705	2.80	.....	43.7	.....	.....	.....	.....	.....	.....	.....	61	.....
1898	1,479,803	1.57	2,359	7	.....	.....	.....	216	627	2.90	.....	46.1	.....	.....	.....	.....	.....	.....	.....	62	.....
1899	1,496,451	1.57	2,378	1	.....	.....	.....	238	629	2.64	.....	56.4	.....	.....	65	10	.....	.....	.....	75	.....
1900	1,661,775	1.63	2,376	7	2.95	4.21	237,395	252	699	2.77	.....	62.9	.....	.....	.....	.....	.....	.....	.....	81	.....
1901	1,396,081	1.44	2,158	7	3.24	5.01	199,440	231	647	2.80	.....	53.6	.....	.....	.....	.....	.....	.....	.....	70	.....
1902	1,560,823	1.57	1,938	12	6.19	7.69	130,069	270	805	2.98	.....	44.3	.....	.....	.....	.....	.....	.....	.....	65	.....
1903	1,488,810	1.64	2,155	5	2.32	3.36	297,762	254	691	2.72	.....	46.6	.....	.....	61	2	.....	.....	.....	63	.....
1904	1,358,919	1.61	2,505	9	3.59	6.62	150,991	243	542	2.23	.....	35.5	.....	.....	56	1	.....	.....	.....	57	.....
1905	1,643,832	1.72	2,181	8	3.67	4.87	205,479	243	754	3.10	.....	45.8	.....	.....	55	3	.....	.....	.....	58	.....
1906	1,829,921	1.77	2,394	13	5.43	7.10	140,763	243	764	3.14	.....	53.2	.....	.....	70	6	.....	.....	.....	76	.....
1907	2,016,857	1.94	2,735	13	4.75	6.45	155,143	268	737	2.75	.....	48.8	.....	.....	76	10	.....	.....	.....	86	.....
1908	1,920,190	1.96	3,146	21	6.68	10.94	91,438	224	610	2.72	.....	37.1	.....	.....	53	4	.....	.....	.....	57	.....
1909	2,553,940	1.97	4,535	11	2.43	4.31	232,176	(a)	563	(a)	.....	32.9	.....	.....	72	9	.....	.....	.....	81	60
1910	2,920,970	1.82	3,837	12	3.13	4.11	243,414	239	761	3.18	.....	29.7	.....	.....	65	32	1	1	.....	99	57

1911	2,976,358	1.79	3,864	14	3.62	4.70	212,597	220	770	3.50	25.7	39.4	39.4	1.0	56	18	.....	11	2	87	49
1912	3,045,495	1.82	3,440	7	2.03	2.30	435,493	220	886	4.03	30.3	32.3	36.9	.5	38	21	.....	8	2	69	49
1913	3,240,973	1.74	3,630	20	5.51	6.17	162,049	228	893	3.92	31.0	33.2	35.3	.5	53	22	.....	19	3	97	43
Total	41,400,059	.....	.....	204	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (1900–1913)	2,115,597	.....	2,921	11.36	3.89	5.37	188,276	239	734	3.08	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	2,805,173	1.75	3,350	8	2.39	2.85	350,647	209	837	4.00	24.2	43.3	31.9	.6	57	21	.....	20	1	99	44

a Not reported.

b Figures in italics represent incomplete fatality records.

TABLE 112.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN MONTANA, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE DURING THE CALENDAR YEARS 1890 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1889																										0
1890		1											1													1
1891	3	1	2			1							7													7
1892	1		2										3													3
1893	1												1													1
1894	5					1							6													6
1895 [a]	4			1		2			1				8													8
1896 [b]																										
1897	3	3	5										11													11
1898 [a]	1	4	*c 1*			1						1	7													7
1899			*c 1*										1													1
1900	1	3	1			2							7													7
1901	3		1									2	6								1				1	7
1902	2	1	1			1						7	12													12
1903	4		1										5													5
1904	6	1	2										9													9
1905	5	2	1										8													8
1906	2	2						1			8		13													13
1907	7	1	1										9								2			2	4	13
1908	3	4	2			1					9		19										1	1	2	21
1909	6	2	2			1							11													11
1910	4	3	5										12													12
1911	7	3	2			2							14													14
1912	2	1	2			2							7													7
1913	9	4	2			2							17			1		1					2		2	20
1914	6		1										7						1						1	8

[a] 11 months. [b] No report. [c] Figures in italics represent incomplete fatality records.

NEW MEXICO.

AREA AND DISTRIBUTION OF COAL FIELDS.

The coal fields of New Mexico comprise about 13,000 square miles but most of this large area is undeveloped and the producing districts are small and widely scattered.

The most important field, both as regards quality of coal and amount produced, is the Raton field, which is the southward continuation of the Trinidad field of Colorado. It extends about 40 miles south of the State line to the Cimarron River, and from the base of the Rocky Mountain Range eastward about 50 miles. Its area is about 960 square miles.

The largest area is the San Juan River region in the northwestern corner of the State. Its area is about 10,000 square miles, but only two small districts in this great field are developed at present. These are Gallup, on the Santa Fe Railroad, at the southern end of the field, and Monero, or Lumberton, at the north end. The coal at Gallup is subbituminous, and at Monero bituminous. The Los Cerrillos field, in the central part of Santa Fe County, contains about 35 square miles, and is noteworthy as the only western field outside of Colorado that is producing anthracite. Operations in the White Oaks field of Lincoln County are small, and the production is limited to local consumption. Mining on a small scale is also carried on at Carthage, in Socorro County, in a small isolated field containing bituminous coking coal.

CHARACTER OF COAL BEDS.

Practically all of the coal mined in the Raton field comes from a few large mines working the lowest bed of coal. This bed varies from 4 to 12 feet thick. There are at least four other coal beds thick enough to be of economic importance, although comparatively little development has been done on them. The second bed from the bottom, known as the Sugarite coal, has been opened east of Raton at the Sugarite mine, and the third bed has been developed to some extent at Yankee, and is believed by some to be the same as the coal bed opened at Brilliant, which is situated in Dillon Canyon, northwest of Raton. No producing mines have been opened on the higher coal beds. The coal beds in the Raton field lie nearly flat, and mining is not particularly dangerous, except for gas in some of the mines.

In the Gallup district the coal beds, as a rule, lie nearly flat, except on the rim of the basin, 3 miles east of Gallup, where they sharply upturn. There are five coal beds in this district, ranging in thickness from 2½ to 7 feet.

The coal beds of the Los Cerrillos field dip about 18° east. There are three important beds, varying in thickness from 2½ to 7 feet with the higher grade of coal in the northern part of the field. The northern part also contains some anthracite coal which has been produced by an intrusion of igneous rock, and which gradually merges into coking and semicoking coals to the south.

The only other field in which active mining is carried on is a few miles east of Socorro. This field contains coking coal, but the beds are so broken by faults and covered by recent material washed in from the surrounding higher land that mining is expensive and uncertain.

MINING METHODS.

The records of coal production in New Mexico extend back to 1882, during which year 157,092 tons of coal were produced. The production has gradually increased until in 1913 the total amount was 3,708,806 tons. In 1898 the 29 mining machines in use produced 16.5 per cent of all the coal mined. During 1905 and 1906 there were no mining machines in operation, but in 1907 three machines were introduced, and the number has gradually increased until in 1914 45 machines produced 16 per cent of the coal. In 1911 31.2 per cent of the coal was shot off the solid, but with the increase in the amount of machine-mined coal the amount shot off the solid was reduced to 17.6 per cent in 1913. From 65 per cent to 75 per cent of the coal is mined by hand.

The coal mines of New Mexico are operated on single and double entry systems through slopes and drifts. One large company operates a triple-entry system. Coal is mined by the room-and-pillar method. In 1913 there were three longwall mines and three panel-system mines. Many of the mines are very dry, and humidifiers have been installed. Shot firers are employed. Mule, horse, and electric haulage are in use. The following extracts[a] are from the State mine inspector's report for 1910.

The Tocco mine, near Albuquerque, has the distinction of operating the thinnest coal seam developed in New Mexico, one of the thinnest worked in the United States, and one that ranks also with the thinnest mined in Europe. The seam is from 12 to 15 inches thick, with 1 to 3 inches of bony coal at the top, leaving 10 to 13 inches of clean coal to be mined. A slope has been sunk 355 feet, with an average dip of 25°, and cross entries have been driven about 30 feet apart. The props used are from 10 to 13½ inches long. The coal is bituminous, free from sulphur, and is a good blacksmith's coal. The product of the mine is hauled to Albuquerque, N. Mex., where it is sold for blacksmithing purposes at from $9 to $12 per ton of 2,000 pounds.

The mines at Dawson are worked as follows:

Triple main entry; double-cross entry; room-and-pillar, robbing on retreat. All main drift entries are 10 feet wide by 6 feet high; main cross entries, 8 feet by 6 feet.

[a] State mine inspector's report, 1910, pp. 17, 20.

Cross entries off cross entries are 8 feet wide by 5 feet 6 inches high; main air courses are 10 feet by 6 feet and other air courses 8 feet wide by 6 feet. All workings are substantially timbered and haulage ways and traveling roads are lighted by electricity. Main entry pillars are from 100 to 300 feet thick; main cross entry pillars, 50 to 100 feet. Average length of rooms, 350 feet; room centers, 60 feet; width of rooms, 20 feet; size of room pillars, 40 feet. The mines are ventilated by exhaust fans on the surface. Shots are fired by electricity after all persons are out of the mine.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

By an act of Congress approved March 3, 1891, official inspection of coal mines was authorized in all Territories where the aggregate annual production of such mines exceeded 1,000 tons. The appointment of the inspector was vested in the President of the United States. Under the provisions of this law, the first mine inspector for the Territory of New Mexico was appointed July 1, 1892, and entered upon duty August 30, 1892. Section 15 of the act provided that a full and written report of all fatal accidents should be made to the mine inspector within 10 days after such death shall have occurred. Annual reports for fiscal years ending June 30 were rendered to the Secretary of the Interior. New Mexico was admitted to the Union on January 6, 1912, and the former Territorial mine inspector was continued in office. The office of State mine inspector was created by an act approved June 13, 1912, and the first State inspector was appointed September 20, 1912. The State law requires mine operators to keep a record of all accidents at their mines, to which record the inspector shall have access, and to at once report to the inspector by telegraph or telephone all accidents resulting in death, such immediate report to be followed, within 10 days, by a full and complete written report of the accident. It was made the inspector's duty to proceed without delay to any mine within the State upon receipt of notice of any explosion or other accident resulting fatally or jeopardizing the lives of the men working in such mine. Annual reports are rendered to the governor for years ending November 30.

According to the State inspector, the number of nonfatal accidents published in his annual report is not complete, as the reporting of such accidents is not made compulsory by law, and some operators do not report all injuries at their mines.

In 1915 the State inspector had no clerical or other assistants.

ACCIDENTS.

Tables 113 and 114 show by causes and calendar years the total number of fatalities in and about the mines of New Mexico, since the beginning of inspection service in 1893 to the end of 1913, as compiled from the territorial and State mine inspectors' reports. The

21-year period from 1893 to 1913 shows 568 fatalities, of which 56.51 per cent was due to gas and dust explosions, 28.17 per cent to falls of roof and pillar coal, and 7.57 per cent to mine cars and locomotives. The fatality rate for New Mexico is exceedingly high by reason of the disaster at Dawson, in which 263 men were killed at one time.

FATALITIES IN NEW MEXICO COAL MINES, BY PRINCIPAL CAUSES, DURING THE YEARS 1893 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	160	28.17	3.22
Mine cars and locomotives	43	7.57	.87
Gas and dust explosions	321	56.51	6.46
Explosives	24	4.23	.48
Miscellaneous	16	2.82	.32
Shaft	0		
Surface	4	.70	.08
Total, 21 years	568	100.00	11.43

COAL-MINE ACCIDENTS IN NEW MEXICO IN WHICH 5 OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Nature of accident.	Number killed.
1895 Feb. 27	White Ash	Cerrillos	Mine explosion	24
1899 Apr. 21	Cook and White	Madrid	do	5
1903 June 19	Blossburg No. 3	Blossburg	do	5
1906 Oct. 5	Dutchman	do	do	10
1907 Dec. 31	Bernal	Carthage	do	11
1913 Oct. 22	Stag Canon No. 2	Dawson	do	263

The fatality rate during this period is 11.43 per 1,000 men employed. By referring to Table 40 it will be noted that the fatality rate for common accidents—that is, those in which less than 5 men were killed at one time—based on the actual number of employees is 4.84 per 1,000 men, for the 10-year period 1903 to 1913, inclusive, excepting 1909. The number of fatalities due to exceptional accidents—that is, those in which 5 or more men were killed at one time—is 9.70 for the same 10 years. The fatality rate due to common accidents is a little higher than in a number of other States. The one disaster at Dawson overshadows all others and for this reason the total rate is exceedingly high. Table 40 also shows that the number of hours worked per year per man is 2,463, as compared with 1,495 for Ohio and 2,034 for the bituminous mines of Pennsylvania. By reducing the fatality rate of common accidents to the basis of 2,000-hour workers, the rate becomes 3.93 as compared with 3.84 for Ohio and 2.82 for the bituminous mines of Pennsylvania.

NUMBER OF HOURS TO THE WORKING DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN NEW MEXICO.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, or 10 hours per day.	Total number of men employed.
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	7	99	1	3	13	1,309	378	1,789
1904	6	78	1	31	15	1,680	60	1,849
1905	4	83	5	92	12	1,923	10	2,108
1906	8	78	2	24	16	1,856	112	2,070
1907	8	79	4	287	14	2,584	20	2,970
1908	5	30	6	356	14	3,015	47	3,448
1909[b]								3,317
1910	5	21	5	185	16	3,345	34	3,585
1911	2	5	6	167	22	3,516	12	3,700
1912	2	4	6	140	23	3,777	7	3,928
1913	16	2,335	8	401	10	1,590	3	4,329

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN NEW MEXICO AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day. (all employees).	Total hours per year.	Number of 2,000-hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	260	17,311	4,500,860	2,251	22	9.77
1904	228	18,243	4,159,404	2,080	8	3.85
1905	234	20,812	4,870,008	2,435	7	2.87
1906	242	20,408	4,938,736	2,469	23	9.32
1907	269	29,235	7,864,215	3,932	34	8.65
1908	197	34,017	6,701,349	3,351	24	7.16
1909						
1910	283	35,589	10,071,687	5,036	16	3.18
1911	230	36,811	8,466,530	4,233	11	2.60
1912[b]	274	39,125	10,720,250	5,360	16	2.99
1913	289	38,216	11,044,424	5,522	272	49.26

From 1903 to the close of 1912 practically all of the men in the mines of New Mexico were employed on a 10-hour basis, but in 1913 the majority of the men were employed 8 hours a day. Table 41 shows the fatality rates on the 2,000-hour basis for a period of years, so that a comparison with other States may be easily made. The tables of statistics for the State of New Mexico follow:

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN NEW MEXICO.[a]

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899				1904	556	78,090	131
1900				1905 to 1912			
1901	766	32,949	43	1913	8	1,040	130
1902	470	9,820	21	1914			
1903	54	710	13				

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 113.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN NEW MEXICO, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.

[Total production and all items below horizontal lines in various columns selected from Mineral Resources, U. S. Geol. Survey. Figures in column 4 and items above horizontal lines in columns 2 and 21 from State mine inspectors' reports. Figures in columns 5, 6, and 7 and averages in columns 9 and 10 prior to 1900 calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reporting.	Pick.	Chain breast.	Long wall.	Short wall.	Radial axe or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1882–1888	2,301,182																				
1889	486,943	$1.79	1,015					(a)	480												
1890	375,777	1.34	827					192	454	2.36											
1891	462,328	1.68	806					265	574	2.17											
1892	661,330	1.62	1,063					223	611	2.74											
1893	665,094	1.47	1,011	4	3.96	6.01	166,274	229	658	2.87											
1894	597,196	1.57	935	11	11.17	18.42	54,291	182	606	3.33											22
1895	720,654	1.49	1,353	28	20.25	38.85	25,738	190	521	2.74											21
1896	622,626	1.49	1,569	9	5.74	14.45	69,181	172	397	2.31											
1897	716,981	1.38	1,659	5	3.01	6.97	143,396	208	432	2.08											24
1898	992,288	1.35	1,873	8	4.27	8.06	124,036	242	530	2.19		16.5								29	20
1899	1,050,714	1.39	1,750	18	10.29	17.13	58,373	257	600	2.33		24.8				14				14	25
1900	1,299,299	1.37	2,087	9	4.42	6.93	144,367	261	638	2.44		8.6								21	24
1901	1,086,546	1.42	2,478	15	6.05	13.81	72,436	224	438	1.96		.2								6	21
1902	1,048,763	1.43	1,849	14	7.57	13.35	74,912	217	567	2.61		6.8								17	
1903	1,541,781	1.37	1,789	22	12.30	14.27	70,081	260	862	3.32		9.4				12				12	
1904	1,452,325	1.31	1,849	8	4.33	5.51	181,541	228	785	3.44		6.9			2	10				12	
1905	1,649,933	1.33	2,108	7	3.32	4.24	235,705	234	783	3.35											
1906	1,964,713	1.34	2,070	23	11.11	11.71	85,422	242	949	3.92											
1907	2,628,959	1.46	2,970	34	11.45	12.93	77,322	269	885	3.29		.4			3					3	
1908	2,467,937	1.37	3,448	24	6.96	9.72	102,831	197	716	3.63		1.2			7					7	
1909	2,801,128	1.29	3,317	14	4.22	5.00	200,081	(a)	844	(a)						4				4	30
1910	3,508,321	1.39	3,585	16	4.46	4.56	219,270	283	979	3.46		2.0				2	1			3	31
1911	3,148,158	1.44	3,700	11	2.97	3.49	286,196	280	851	3.70	65.4	3.0	31.2	0.4	4	4	2			10	38

1912	3,636,824	1.42	3,928	16	4.07	4.52	221,052	274	900	2.28	74.7	8.1	16.9	.3	7	4	.....	13	1	25	35
1913	3,706,806	1.46	4,329	279	62.93	73.34	13,635	289	857	2.97	68.7	13.4	17.6	.3	7	6	1	30	.....	44	36
Total	41,496,606	.....	.....	558	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (1885–1913)	1,771,859	.....	3,366	27.06	11.43	15.27	65,539	243	749	3.10	65.0	16.0	18.8	.2	9	8	.....	28	.....	45	35
1914	3,877,680	1.61	4,178	13	4.31	4.64	215,427	283	928	3.28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	36

a Not reported.

TABLE 114.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN NEW MEXICO, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE, DURING THE CALENDAR YEARS 1893 TO 1914, INCLUSIVE.

Year.	Killed underground.												Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22			
1893	2	1	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
1894	4	.....	.....	6	.....	1	.....	.....	.....	.....	.....	.....	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11
1895	3	1	.....	24	.....	.....	.....	.....	.....	.....	.....	.....	28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	28
1896	3	.....	3	.....	.....	3	.....	.....	.....	.....	.....	.....	9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9
1897	2	2	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5
1898	4	.....	2	.....	.....	1	.....	.....	.....	.....	.....	.....	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	1	8
1899	9	1	2	5	.....	.....	.....	1	.....	.....	.....	.....	18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18
1900	4	2	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9
1901	6	.....	2	.....	3	2	.....	.....	.....	.....	.....	2	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15
1902	7	.....	4	.....	.....	1	.....	.....	.....	.....	2	.....	14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14
1903	10	1	1	.....	.....	7	.....	.....	.....	.....	3	.....	22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	22
1904	5	1	1	.....	.....	1	.....	.....	.....	.....	.....	.....	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8
1905	5	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7
1906	10	1	2	10	.....	.....	.....	.....	.....	.....	.....	.....	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	23
1907	12	1	5	.....	11	.....	.....	.....	.....	.....	3	.....	32	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	2	2	34
1908	15	1	6	.....	.....	1	.....	.....	.....	.....	.....	.....	23	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	1	1	24
1909	5	4	3	.....	.....	.....	.....	.....	.....	.....	2	.....	14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14
1910	8	6	1	.....	.....	1	.....	.....	.....	.....	.....	.....	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	16
1911	9	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11
1912	8	2	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	16
1913	2	1	2	.....	a 261	2	a 2	.....	.....	.....	.....	1	272	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	272
1914	14	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	16	1	.....	.....	1	.....	.....	.....	.....	.....	1	1	.....	18

a Stag Canyon explosion, killed 263.

NORTH CAROLINA.

AREA AND DISTRIBUTION OF COAL FIELDS.

The coal-bearing formations of North Carolina are contained in the Deep River and the Dan River fields and are of Triassic age. The Deep River field extends from the northern boundary in a southwesterly direction through Durham, Haywood, and Wadesboro, entirely across the State and a short distance into South Carolina. The field averages about 12 miles wide and contains 250 to 300 square miles. The Deep River coal is bituminous and in some places has been more or less coked by igneous intrusions.

CHARACTER OF COAL BEDS.

The coal beds dip about 15° southeast and vary from 1 foot to 8 feet in thickness. Mining has been conducted in this field in a desultory way since the early sixties. From 1860 to 1865 it is estimated that about 65,000 tons of coal was produced. One of the most important mines worked in recent years is the Cumnock, which is opened by a shaft 8 feet by 12 feet in cross section and 460 feet deep. This mine has been the scene of two serious mine explosions in which 62 men were killed.

The Dan River field consists of a small coal-bearing area in the north-central part of the State and is 50 or 60 miles northwest of the Deep River field. The Dan River field extends from the Virginia-North Carolina line in a southwesterly direction and is about 30 miles long and 4 to 7 miles wide. The coal beds are 2 to 7 feet thick and dip about 34°. A small amount of coal was mined from this field during the Civil War, but since that time little mining has been done there.

Tables 115 and 116 give further details concerning the number of men employed, coal produced, accidents, etc. These tables are meager and incomplete, but contain all the data available.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

There is official mine-inspection service[a] in North Carolina, but as the State is not a regular producer of coal, the occasional output is too small to place the industry on a commercial scale. The tables of statistics for this State follow.

COAL-MINE ACCIDENTS IN NORTH CAROLINA IN WHICH 5 OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Nature of accident.	Number killed.
1895 Dec. 19	Cumnock	Cumnock	Mine explosion	39
1899 May 23	do	do	do	23

[a] Revised Statutes, 1905, sec. 4940.

TABLE 115.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN NORTH CAROLINA, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.[a]

[Compiled from Mineral Resources, U. S. Geol. Survey.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reporting.	Pick.	Chain breast.	Long wall.	Short wall.	Radial axe or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1862–1887	229,150																				
1888	250																				
1889	222																				
1890	10,262	$1.74	80						128												
1891	20,355	1.93	80					254	254	1.00											
1892	6,679	1.44	90					160	74	.46											
1893	17,000	1.50	70					80	243	3.04											
1894	16,900	1.76	95					145	178	1.23											
1895	24,900	1.66	61	*39*				226	408	1.81											
1896	7,813	1.50	18					220	434	1.97											
1897	21,280	1.34	51					215	417	1.94											
1898	11,495	1.25	(b)					(b)	(b)	(b)											
1899	26,896	1.30	70	*23*				210	384	1.83											
1900	17,734	1.32	84					151	211	1.40											
1901	12,000	1.25	25					300	480	1.60											
1902	23,000	1.50	40					285	575	2.02											
1903	17,309	1.47	49					264	353	1.34											
1904	7,000	1.50	25					240	280	1.17											
1905	1,557	1.50	15					60	104	1.73											
1906																					
1907																					
1908																					
1909																					
1910				0																	
1911	120			0																	
1912	200			0																	
1913				0																	
Total	477,125			*62*																	

[a] Figures in italics represent incomplete fatality records.

[b] No record.

NORTH DAKOTA.

AREA AND DISTRIBUTION OF COAL FIELDS.

The coal beds of North Dakota are lignitic, and occupy about 35,000 square miles, or practically the western half of the State. Ninety-seven townships contain at least one bed of lignite 7 feet thick, and at least 100 other townships contain beds 4 to 7 feet thick. The lignite beds are horizontal and occur at depths ranging from near the surface to a depth of at least 300 feet.

MINING METHODS.

Lignite has been mined in North Dakota by ranchers and others since the territorial days of the State, and the first records of production were obtained in 1884, when 35,000 tons of coal was mined.

The production in 1913 was 495,322 tons.

In 1911 there were practically 100 mines in operation, 20 of which were surface and 80 underground mines. Of the underground mines, 69 were opened by slope or drift and 11 by shaft. The mines are opened by single and double entry and the coal mined by the room-and-pillar method, the rooms being 12 by 100 feet to 22 by 300 feet; pillars are 8 to 20 feet wide. The length of entries varies from 100 to 5,000 feet. In 1911, there were 15 mines with entries over 1,000 feet long. The largest number of deep mines is in Ward County, where the mines vary from surface pits to 200 feet in depth; 21 mines are over 100 feet deep. In Adams County the deepeest mine in 1911 was 300 feet.

Ventilation is usually by an air shaft in connection with slope, drift, or entry.

Mining machines have been in use in a limited way since 1896. In 1914 there were 14 machines in operation, producing 41.1 per cent of the coal mined. Twenty-six per cent was shot off the solid and 6.3 per cent was mined by hand.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

The State engineer of North Dakota was made ex-officio State coal-mine inspector by an act approved March 14, 1907, with power to employ necessary assistants. The engineer renders biennial reports to the governor, showing the condition of each mine, number of men employed, and such other information as he deems desirable.

The law does not require operators to notify the inspector of mine accidents, but the inspector has requested the operators to report all accidents, however slight. All accidents thus reported are published in the biennial reports of the inspector. No distinction is made between serious and slight injuries.

ACCIDENTS.

Tables 116 and 117 show the total number of fatalities in and about the coal mines of North Dakota from 1908 to the end of 1913, as compiled from the State mine inspectors' reports. During the 6-year period 1908 to 1913, inclusive, there were 13 fatalities, of which 46.16

FATALITIES IN NORTH DAKOTA COAL MINES, BY PRINCIPAL CAUSES, DURING THE YEARS 1908 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	6	46.16	1.44
Mine cars and locomotives	2	15.38	.48
Gas and dust explosions			
Explosives	3	23.08	.72
Miscellaneous	2	15.38	.48
Shaft			
Surface			
Total, 6 years	13	100.00	3.12

per cent were due to falls of rock, 23.08 per cent to explosives, and 15.38 per cent to mine cars and locomotives. The production per fatality during this period was 203,020 tons, or there were 4.93 fatalities per million tons mined. North Dakota has been fortunate in that there have been no serious mine disasters in that State. The fatality rate during this period is 3.12 per 1,000 men employed.

Since 1903 practically one-half of the men have been employed on a 10-hour basis. By referring to Table 40 it will be noted that during this period the men averaged 1,974 hours per year. During the

NUMBER OF HOURS TO THE WORKING DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN NORTH DAKOTA.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, and 10 hours per day.	Total number of men employed.
	Number of mines.	Men employed.	Number of mines	Men employed.	Number of mines.	Men employed.		
1903	6	40	8	90	20	263	93	486
1904	8	66	11	117	20	292	79	554
1905	8	79	7	50	20	374	123	626
1906	6	47	4	38	20	323	80	486
1907	11	89	6	119	17	304	50	562
1908	11	103	5	114	14	275	139	631
1909 [b]								972
1910	11	94	6	75	16	327	38	534
1911	12	115	4	46	24	423	176	760
1912	12	59	4	51	23	415	97	622
1913	13	61	5	51	24	472	57	641

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN NORTH DAKOTA AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day (all employees).	Total hours per year.	Number of 2,000-hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	198	4,597	910,206	455	.....	.....
1904	192	5,212	1,000,704	501	.....	.....
1905	187	5,929	1,108,723	555	.....	.....
1906	209	4,668	975,612	488	.....	.....
1907	223	5,278	1,175,879	588	.....	.....
1908	181	5,851	1,059,031	530	4	7.55
1909	.....	.....	.....	.....	.....	.....
1910	207	5,039	1,043,073	522	2	3.83
1911	229	7,148	1,636,892	818	1	1.22
1912	232	5,954	1,381,328	691	.....	.....
1913	221	6,180	1,365,780	683	6	8.78

5-year period 1908 to 1913 (exclusive of 1909) for which complete data are available, the fatality rate based on the actual number of employees is 4.08 as compared with 4.01 based on the number of 2,000-hour workers. Table 41 shows the figures on the 2,000-hour basis for a period of years by States, so that a comparison with other States may be readily made.

The tables for the State of North Dakota follow:

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN NORTH DAKOTA.[a]

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899	.....	.....	.....	1907	82	736	9
1900	.....	.....	.....	1908	104	1,620	16
1901	32	224	7	1909	75	525	7
1902	8	8	1	1910	.....	.....	.....
1903	35	340	10	1911	34	69	2
1904	175	6,300	36	1912	10	20	2
1905	.....	.....	.....	1913	.....	.....	.....
1906	37	92	2	1914	.....	.....	.....

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 116.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN NORTH DAKOTA, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.

[Figures for total production and all items below horizontal lines in various columns selected from Mineral Resources, U. S. Geol. Survey. Figures for column 4 compiled from State mine inspectors' reports. Figures for columns 5, 6, and 7 and averages in columns 9 and 10 prior to 1900 calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reporting.	Pick.	Chain breast.	Long wall.	Short wall.	Radial axe or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1884–1888	141,425																				
1889	28,907	$1.43	75					(a)	385												
1890	30,000	1.40						(a)													
1891	30,000	1.40						(a)													
1892	40,725	.96	54					216	754	3.49											
1893	49,630	1.13	88					193	564	2.92											
1894	42,015	1.12	77					156	546	3.50											
1895	38,997	1.07	65					139	600	4.32											
1896	78,050	1.09	141					166	554	3.34		19.2								1	
1897	77,246	1.08	170					168	454	2.70		25.9								2	
1898	83,895	1.12	151					187	556	2.97		77.5								7	
1899	98,809	1.19	210					154	471	3.06		38.5			4	1				5	
1900	129,883	1.22	326					142	398	2.80		26.1								7	
1901	166,601	1.29	280					198	595	3.01		26.1								7	
1902	226,511	1.44	402					213	563	2.64		39.7								10	
1903	278,645	1.50	486					198	573	2.89		41.4			2	7				9	
1904	271,928	1.43	554					192	491	2.56		46.0			1	8				9	
1905	317,542	1.34	626					187	507	2.71		30.8				9				9	
1906	305,689	1.54	488					209	626	3.00		31.7				11				11	
1907	347,760	1.61	562					223	619	2.78		39.3				12				12	
1908	320,742	1.63	631	4	6.34	12.47	80,186	181	508	2.81		32.7				9	2			11	
1909	422,047	1.53	972	0				(a)	434	(a)		27.3			7	9				16	58
1910	399,041	1.49	534	2	3.75	5.01	199,521	207	747	3.61		41.4			4	9				13	44

1911	502,628	1.42	760	1	1.32	1.99	502,628	229	661	2.89	13.3	38.4	26.6	21.7	.....	11	.....	.....	.....	11	60
1912	490,490	1.53	622	0	.....	.....	.....	232	803	3.46	14.2	33.8	26.4	15.6	.....	11	.....	.....	.....	11	51
1913	495,320	1.52	641	6	9.36	12.11	82,553	221	778	3.50	11.1	44.9	26.3	17.7	.....	4	.....	9	.....	13	55
Total	5,423,516	.....	.....	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (1908–1913)	439,876	.....	698	2.16	3.12	4.93	208,690	215	633	2.94	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	506,685	1.52	558	3	5.38	5.92	168,895	216	908	4.20	6.3	41.1	38.2	14.4	.....	14	.....	.....	.....	14	52

a Not reported.

TABLE 117.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN NORTH DAKOTA, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE, DURING THE CALENDAR YEARS 1908 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1908 a	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1909	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1910	1	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1911	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1912	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1913	3	.....	2	.....	.....	1	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	1	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

a From Mineral Resources, U. S. Geol. Survey.

OHIO.

AREA AND DISTRIBUTION OF COAL FIELDS.

The coal-bearing area of Ohio covers about 12,600 square miles, and occupies 30 counties in the southeastern part of the State. It is a part of the northwestern side of the great Appalachian coal basin which stretches from northern Pennsylvania to central Alabama. As it lies on the northwestern side of the basin the general dip of the beds is southeast toward the middle, but there are a few small folds which break up the continuity of the southeastward dip, and in some places cause a dip in the opposite direction. The most pronounced fold of this kind trends north to south and enters the State near Marietta. The coal beds and associated rocks extend to the northeast into West Virginia and Pennsylvania and to the southwest into Kentucky.

CHARACTER OF COAL BEDS.

The coal beds of Ohio are numbered from the bottom upward, coal No. 1 being the lowest bed. Coal No. 1 has been most extensively developed in the northern part of the State, but it occurs in isolated areas along the west side of the field. It is from 3 to 6 feet thick at Brier Hill and at Massillon. The roof is shale ranging from 5 to 40 feet in thickness. The coal is jointed, hence its name, block coal. It is noncoking, but of good steaming quality. The No. 2, or Wellston bed, is 45 to 75 feet above No. 1 and is seldom more than 2 feet thick, although at Wellston, Jackson county, it is 4 feet thick. The roof is shale and the coal non-coking.

The No. 5 bed, or Lower Kittanning, extends in an almost unbroken outcrop across the State. It is mined in almost every county of the Ohio coal field from southern Mahoning on the north to Hanging Rock on the south. It is generally less than 3 feet thick, but at Mineral Point, Zanesville, and New Castle, it is 4 to 5 feet thick. The coal is of good coking quality, but because of the thinness of the bed mining machines are not used extensively, the coal being largely mined by pick mining.

No. 6 bed, or the Middle Kittanning, also extends under a wide area. In the northern part of Columbiana County it is less than 1 foot thick. In the southern part of the county it is worked extensively, although it is only 20 to 30 inches thick. In Coshocton County, it attains a thickness of 3 feet to 4 feet 10 inches. At Shawnee it is known as the Hocking Valley seam, and in many places contains 10 feet of mineable coal. From 32 to 38 per cent of the State's production comes from this bed.

The No. 7, or Upper Freeport, is not so extensive as the lower beds and varies in thickness from 5 feet 4 inches to 6 feet 9 inches. This is one of the best steaming coals in the State.

The No. 8, or Pittsburgh, is the most important bed of the upper coal measures. The coal rests on a bed of fire clay and is 4 to 6 feet thick. This bed extends into West Virginia and into Pennsylvania.

MINING METHODS.

The accompanying table shows the number of mines opened by shaft, slope or drift, from 1892 to 1912, inclusive. At first the single-entry system of mining prevailed, but in the early eighties the double-entry system was introduced in a number of the larger mines, and now, although the single-entry system still prevails in some mines where the bed is thin, most of the mines are opened by the double-entry system, also some are opened by the three-entry system.

Mining machines are used extensively in coal beds Nos. 6, 7, and 8. Prior to 1877 all of the coal mined in Ohio was mined by pick. During this year the first mining machines were introduced in the State and the use of machines has steadily increased until in 1913 there were 1,681 machines in operation, producing 21,535 tons each, or in all 90.2 per cent of the coal of the State. The electric machines were introduced in Ohio in 1889 and their number has gradually increased to 1,604 in 1913. In 1891, 89 compressed-air machines were in use in Ohio mines and in 1905 the highest number, 145, was reached. There were only 49 in operation in 1913. Less than 4 per cent of the coal is reported as being shot off the solid, and slightly over 4 per cent as being mined by hand.

Prior to the introduction of mining machines in Ohio, the coal-mining work was performed principally by skilled miners from England, Scotland, and Germany. This class of miners has gradually been supplanted in the State by labor from southern Europe. The table on methods of opening and ventilation at Ohio mines follows:

NUMBER OF COAL MINES IN OHIO, CLASSIFIED BY TYPE OF OPENING AND METHOD OF VENTILATION FROM 1892 TO 1913, INCLUSIVE.[a]

Year.	Mines opened by—					Method of ventilation.						
	Drift.	Shaft.	Slope.	Small mines, kind of opening unknown.	Total.	Fan.	Furnace.	Fire baskets.	Steam jets and exhaust from pumps.	Natural.	Small mines, mode of ventilation unknown.	Total.
1892	303	91	40	458	892	127	253	11	30	205	266	892
1893	676	121	61	151	1,009	141	323	23	39	316	167	1,009
1894	657	149	61	296	1,163	139	264	32	43	378	309	1,165
1895	749	150	68	220	1,187	134	278	36	48	452	242	1,190
1896	821	149	66	167	1,203	134	281	38	52	528	179	1,212
1897	800	153	85	190	1,228	149	280	51	49	516	200	1,245
1898	921	143	145	46	1,255	149	317	45	47	636	73	1,267
1899	789	145	133	65	1,132	147	274	41	34	523	107	1,126
1900	696	122	140	114	1,072	171	264	48	33	453	103	1,072
1901	625	133	149	99	1,006	182	253	40	44	389	98	1,006
1902	589	140	142	96	967	219	222	57	45	336	88	967
1903	591	142	140	81	954	259	244	44	32	302	73	954
1904	638	153	142	85	1,018	282	254	50	34	320	78	1,018
1905	626	130	125	.....	881	289	239	36	13	304	.....	881
1906	696	163	144	.....	1,003	299	252	38	13	401	.....	1,003
1907	691	140	149	.....	980	322	235	37	19	367	.....	980
1908	742	140	171	.....	1,053	314	236	46	14	443	.....	1,053
1909	744	130	158	.....	1,032	302	240	42	19	429	.....	1,032
1910	726	110	147	.....	983	318	225	35	14	391	.....	983
1911	702	114	132	.....	948	345	191	26	14	372	.....	948
1912	703	113	125	.....	941	350	195	30	11	355	.....	941
1913	707	109	128	.....	944	355	187	35	14	353	.....	944

[a] State mine inspector's reports.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

By an act approved March 21, 1874, the Legislature of Ohio provided for the inspection of all coal mines in which more than 10 men were employed at one time. Under this act the first State inspector was appointed April 6, 1874, and entered upon his duties the following day. The act made it the duty of any person having charge of any mine to which the law was applicable to report forthwith to the State inspector and the county coroner any explosion or other accident causing loss of life. The inspector was required to render a report to the governor on or before the 1st day of January of each year, and to enumerate therein, among other things, all accidents in or about the mines.

On April 12, 1884, the State was divided into three districts, and the enforcement of the laws relating to mining was intrusted to a chief mine inspector and three district inspectors. The inspection service was also extended to include fire-clay, iron-ore, and other mines, as well as coal mines. The number of districts and district inspectors was increased by statute from time to time, until in 1913 there were 12 districts, each having an inspector. On March 12, 1913 a law was passed, and approved March 18, 1913, discontinuing

various State departments and offices, among them being the office of chief mine inspector, and transferring all powers and duties of the inspector to a newly created State industrial commission. Under the provisions of this law, the new commission assumed the duties and functions of the chief inspector of mines on September 1, 1913, and established the office of chief deputy and safety commissioner of mines.

All accidents are reported to district inspectors and are included in the annual reports of the industrial commission. Injuries involving disability for three weeks or more are classified as serious, and all other injuries are slight.

ACCIDENTS.

Tables 118 and 119 show the total number of fatalities by causes since the beginning of inspection service in 1874 with the exception of the fiscal year 1879, for which no report was published. These tables also show the percentage of accidents, classified by principal causes, and fatality rates per 1,000 men employed for a period of 30

FATALITIES IN OHIO COAL MINES, BY PRINCIPAL CAUSES, DURING THE YEARS 1884 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	1,509	65.84	1.57
Mine cars and locomotives	277	12.08	.29
Gas and dust explosions	64	2.79	.07
Explosives	161	7.02	.17
Miscellaneous	115	5.02	.12
Shaft	79	3.45	.08
Surface	86	3.80	.09
Total, 30 years	2,292	100.00	2.39

COAL-MINE ACCIDENTS IN OHIO IN WHICH 5 OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Nature of accident.	Number killed.
1877 July 11	Brookfield	Brookfield	Suffocated by gas from mine locomotive.	7
1881 Feb. 10	Robbins	Robbins	Mine explosion	6
1906 Nov. 3	San Toy No. 1	Corning	Fell down shaft	5
1910 Apr. 21	Amsterdam	Amsterdam	Mine explosion	15
1913 May 17	Imperial	Belle Valley	do	15

years (1884–1913), for which complete records of employees and fatalities are available. The fatality rate during this period is 2.39 per 1,000 men employed. Ohio has been fortunate in the matter of large disasters, there being only 3 during this period causing the death of more than 5 men at one time, representing only 1½ per cent

of the total number killed. Falls of roof and pillar are responsible for 65.84 per cent of the fatalities; mine cars and locomotives are second with 12.08 per cent. The average production of coal per fatality during this period was 251,152 tons, or 3.98 fatalities for each million tons mined.

Since 1903 more than 97 per cent of the men employed in the mines have been on an 8-hour day. The time element, therefore, has been taken into consideration and tables compiled on this basis for comparison with other States. The fatality rate for the 10-year

NUMBER OF HOURS TO THE WORKING DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN OHIO.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, and 10 hours per day.	Total number of men employed.
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	538	39,876	15	455	14	206	1,399	41,936
1904	574	42,845	9	296	7	77	416	43,634
1905	524	42,262	7	527	4	27	583	43,399
1906	461	44,003	8	174	3	76	1,185	45,438
1907	490	44,733	4	53	2	31	2,016	46,833
1908	510	45,742	8	1,004	3	35	626	47,407
1909[b]								38,114
1910	587	45,001	12	249	1	5	1,386	46,641
1911	566	44,351	7	378	3	8	722	45,459
1912	581	44,180	11	474	1	10	963	45,587
1913	604	45,487	8	187	3	32	109	45,815

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN OHIO AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day (all employees).	Total hours per year.	Number of 2,000-hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	194	337,754	65,524,276	32,762	124	3.78
1904	175	349,938	61,239,150	30,620	117	3.82
1905	176	348,356	61,310,656	30,655	126	4.11
1906	167	365,015	60,957,505	30,479	131	4.30
1907	199	376,795	74,982,205	37,491	154	4.11
1908	161	380,956	61,333,916	30,667	113	3.68
1909						
1910	203	374,773	76,078,919	38,039	159	4.18
1911	179	364,788	65,297,052	32,649	107	3.28
1912	201	365,573	73,480,173	36,740	135	3.67
1913	206	366,880	75,577,280	37,789	165	4.37

period 1903 to 1913 (Table 40) based upon the actual number of employees is 2.94, whereas based on the number of 2,000-hour workers it is 3.94. During the 10-year period the men averaged 1,495 hours of labor per man, as compared with 2,132 hours in West Virginia, and 2,034 hours in the bituminous mines of Pennsylvania. Table 41 shows the fatality rate for each year on the 2,000-hour

basis for each State, so that a true comparison of Ohio with other States may be readily made. The tables of statistics for the State follow.

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN OHIO.

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899	877	26,394	30	1907	6,367	110,324	17
1900	2,035	45,547	22	1908	21,084	567,450	27
1901	2,724	105,177	38	1909	2,375	139,434	59
1902	3,769	70,534	19	1910	24,746	1,334,631	54
1903	4,115	65,149	16	1911	9,530	350,039	37
1904	11,412	514,658	45	1912	27,200	895,777	32
1905	3,250	49,495	15	1913	10,029	263,234	26
1906	37,636	2,687,288	71	1914	40,577	6,452,762	159

a Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 118.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN OHIO, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.

[Figures for total production and all items below horizontal lines in various columns selected from Mineral Resources, U. S. Geol. Survey. Figures in column 4 and items above horizontal lines in columns 2, 3, 8, 11, 12, 20, and 21 from State mine inspectors' reports. Figures in columns 5, 6, and 7, and averages in columns 9 and 10 prior to 1900, calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial ax or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1838–1873	45,727,704																				
1874	3,267,585		13,750	29	2.11	8.88	112,675		238												
1875	4,864,259		15,039	24	1.60	4.93	202,677		323												
1876	3,500,000		15,000	15	1.00	4.29	233,333		233												
1877	5,250,000		14,300	31	2.17	5.90	169,355		367												
1878	5,500,000			[a] 17																	
1879	6,000,000			[b] 2																	
1880	6,006,595		16,972	[a] 23																	
1881	9,240,000			30																	
1882	9,450,000		18,000	25	1.39	2.65	378,000		525												
1883	8,229,429			22																	
1884	7,640,062		20,101	32	1.59	4.19	238,752	199	380	1.91											
1885	7,816,179	$1.05	19,704	29	1.47	3.71	269,523	201	397	1.98											344
1886	8,435,211	.95	20,437	42	2.06	4.98	200,838	206	413	2.00											353
1887	10,300,708	.88	22,237	30	1.35	2.91	343,357	228	463	2.03											399
1888	10,910,951	.93	21,801	32	1.47	2.93	340,967	(c)	500												435
1889	9,976,787	.94	19,343	34	1.76	3.41	293,435	(c)	516		91.7	8.3									474
1890	11,494,506	.94	20,576	39	1.90	3.39	294,731	201	559	2.78	90.3	9.7									446
1891	12,868,683	.94	22,182	38	1.71	2.95	338,650	206	580	2.82	87.3	12.7								114	403
1892	13,562,927	.94	22,576	43	1.90	3.17	315,417	212	601	2.83	84.7	15.3								129	434
1893	13,253,646	.92	23,931	36	1.50	2.72	368,157	188	554	2.95	82.8	17.2								148	419
1894	11,909,856	.83	27,105	39	1.44	3.27	305,381	136	439	3.23	78.5	21.5								171	433
1895	13,355,806	.79	24,644	51	2.07	3.82	261,879	176	542	3.08	77.2	22.8								164	424
1896	12,875,202	.79	25,500	42	1.65	3.26	306,552	161	505	3.14	73.8	26.2								209	406
1897	12,196,942	.78	26,410	39	1.48	3.20	312,742	148	462	3.12	68.5	31.5								224	414

1898	14,516,867	.83	26,986	48	1.78	3.31	302,435	169	538	3.18	64.2	35.8								245	425
1899	16,500,270	.87	26,038	56	2.15	3.39	294,648	200	634	3.17	58.7	41.4			18	268				278	417
1900	18,988,150	1.02	27,628	71	2.57	3.74	267,439	215	687	3.20	53.5	46.5								341	432
1901	20,943,807	1.00	32,111	64	1.99	3.06	327,247	198	652	3.29	52.7	47.3								376	437
1902	23,519,894	1.15	38,965	86	2.21	3.66	273,487	200	604	3.02	48.6	51.4								559	446
1903	24,838,103	1.29	41,936	124	2.96	4.99	200,307	194	592	3.05	43.6	56.4			51	673				724	499
1904	24,400,220	1.09	43,634	117	2.68	4.80	208,549	175	559	3.19	42.7	57.3			88	779				867	502
1905	25,552,950	1.04	43,399	126	2.90	4.93	202,801	176	589	3.35	33.9	66.1			128	878	35			1,041	464
1906	27,731,640	1.09	45,438	131	2.88	4.72	211,692	167	610	3.65	27.9	72.1			141	1,081	33			1,255	465
1907	32,142,419	1.10	46,833	154	3.29	4.79	208,717	199	686	3.45	22.7	77.3			109	1,213	6			1,328	481
1908	26,270,639	1.06	47,407	113	2.38	4.30	232,484	161	554	3.44	24.6	75.4			135	1,203	5			1,343	460
1909	27,939,641	.99	38,114	110	2.89	3.94	253,997	(c)	733	(c)	20.5	79.5			97	1,314	22			1,433	550
1910	34,209,668	1.05	46,641	159	3.41	4.65	215,155	203	733	3.61	15.6	84.4			104	1,319	24	5		1,452	690
1911	30,759,986	1.03	45,459	107	2.35	3.48	287,477	179	677	3.78	6.9	86.3	2.8	4.0	92	1,343	54	47		1,536	678
1912	34,528,727	1.07	45,527	135	2.97	3.91	255,768	201	758	3.77	6.8	87.0	3.9	2.3	77	1,362	2	106		1,547	647
1913	36,200,527	1.10	45,815	165	3.60	4.56	219,397	206	790	3.83	4.4	90.2	3.7	1.7	56	1,421	17	187		1,681	667
Total	682,678,546			2,510																	
Average (1884–1913)	19,188,033		31,949	76.40	2.39	3.96	251,152	188	691	3.20											
1914	18,843,115	1.13	45,401	64	1.41	3.40	294,424	108	415	3.84	6.7	85.7	3.8	3.8	56	1,461	24	128		1,669	599

[a] Jan. 1 to Nov. 15.

[b] Nov. 16 to Dec. 31.

[c] Not reported.

TABLE 119.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN OHIO, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE, DURING THE CALENDAR YEARS 1874 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1874	11	5	.....	.....	.....	2	.....	.....	1	.....	.....	8	27	2	1	.....	.....	3	1	.....	.....	2	.....	1	4	34
1875	10	.....	1	.....	.....	3	.....	.....	.....	.....	.....	.....	14	3	4	.....	.....	7	1	.....	.....	.....	.....	2	3	24
1876	8	1	2	.....	.....	2	.....	.....	.....	.....	.....	.....	13	.....	.....	1	.....	1	.....	.....	.....	.....	.....	1	1	15
1877	11	6	9	.....	.....	1	1	.....	.....	.....	.....	1	29	1	.....	1	.....	2	.....	.....	.....	.....	.....	.....	.....	31
1878 [a]	10	.....	1	.....	.....	1	2	.....	.....	.....	.....	2	16	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	17
1879 [b]	1	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
1880 [a]	10	.....	4	.....	.....	4	.....	.....	.....	.....	.....	2	20	1	.....	1	.....	2	1	.....	.....	.....	.....	.....	1	23
1881	9	3	1	6	.....	1	2	.....	.....	.....	.....	2	24	3	.....	1	.....	4	1	.....	.....	1	.....	.....	2	30
1882	16	4	.....	1	.....	1	.....	.....	.....	.....	.....	.....	22	.....	.....	2	.....	2	.....	.....	1	.....	.....	.....	1	25
1883	15	.....	1	.....	.....	3	.....	.....	.....	.....	.....	.....	19	1	.....	2	.....	3	.....	.....	.....	.....	.....	.....	.....	22
1884	13	5	4	1	.....	7	.....	.....	.....	.....	.....	.....	30	2	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	32
1885	18	3	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	24	1	.....	1	.....	2	1	.....	.....	2	.....	.....	3	29
1886	23	8	1	.....	.....	6	.....	.....	.....	.....	.....	.....	38	1	.....	.....	.....	1	.....	.....	.....	1	1	1	3	42
1887	10	10	4	1	.....	3	.....	.....	.....	.....	.....	.....	28	.....	.....	2	.....	2	.....	.....	.....	.....	.....	.....	.....	30
1888	16	9	.....	.....	.....	2	.....	.....	1	.....	.....	.....	28	.....	1	3	.....	4	.....	.....	.....	.....	.....	.....	.....	32
1889	17	7	6	.....	.....	1	.....	.....	.....	.....	.....	.....	31	.....	.....	3	.....	3	.....	.....	.....	.....	.....	.....	.....	34
1890	23	7	3	1	.....	2	1	.....	.....	.....	.....	1	38	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	39
1891	26	4	3	.....	.....	1	.....	.....	1	.....	.....	2	37	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	1	38
1892	21	4	5	.....	.....	5	.....	.....	.....	.....	.....	2	37	3	.....	.....	.....	3	1	.....	.....	.....	1	1	3	43
1893	20	2	5	.....	.....	3	.....	.....	.....	.....	.....	1	31	5	.....	.....	.....	5	.....	.....	.....	.....	.....	.....	.....	36
1894	20	3	2	1	.....	7	.....	.....	.....	.....	.....	.....	33	2	.....	3	.....	5	.....	.....	.....	1	.....	.....	1	39
1895	21	7	7	.....	.....	11	1	.....	1	1	.....	.....	48	.....	.....	1	.....	1	.....	.....	.....	1	.....	.....	1	50
1896	24	7	5	1	.....	2	.....	1	.....	.....	.....	.....	40	.....	.....	1	.....	1	1	.....	.....	.....	.....	.....	.....	41
1897	25	4	3	.....	.....	3	.....	1	.....	.....	.....	.....	36	.....	.....	.....	1	1	.....	.....	.....	1	1	.....	2	39
1898	29	5	4	1	.....	3	.....	.....	.....	1	.....	.....	43	1	1	2	.....	4	.....	.....	.....	.....	1	.....	1	48
1899	34	6	4	.....	.....	4	.....	1	.....	.....	.....	.....	49	.....	.....	4	.....	4	.....	.....	.....	.....	2	1	3	56
1900	40	5	15	3	.....	3	.....	.....	.....	.....	.....	.....	66	2	.....	.....	.....	2	.....	.....	.....	.....	1	2	3	71
1901	31	6	9	3	.....	8	1	1	.....	.....	.....	1	60	1	.....	1	.....	2	.....	.....	.....	2	.....	.....	2	64
1902	53	5	13	3	.....	9	.....	.....	.....	.....	.....	.....	83	.....	.....	1	.....	1	.....	1	.....	1	.....	.....	2	86

| | | |

OKLAHOMA.

AREA AND DISTRIBUTION OF COAL FIELDS.

The coal fields of Oklahoma have an area of about 10,000 square miles. In general the rocks of these fields dip slightly west under the Great Plains, but in Oklahoma the regular westward dip is interfered with by many local folds. On this basis the coal fields of the State may be divided into two parts as follows: (1) that part north of Canadian River in which the rocks are only slightly disturbed, and (2) the part south of Canadian River in which there are many strong anticlines and synclines that make the coal beds dip in various directions and at different angles. The part north of Canadian River is the southward continuation of the Kansas fields, but with the coal beds in greatly reduced thickness. The part south of Canadian River is similar to and a continuation of the folded and faulted fields of Arkansas. Local faults occur in the McAlester anticline near McAlester.

On the northern slope of the McAlester anticline the coal-bearing rocks are tilted until the coal beds are almost vertical, and from Hartshorne to Atoka the beds are also steeply upturned. In this respect the Oklahoma coal fields are similar to those of Washington, certain parts of Colorado, and the anthracite fields of Pennsylvania. They differ from the coal fields of Washington in that the coal has not been crushed or changed in character by structural movement of the inclosing rocks.

The southern part of the coal field is the more important, as more than three-fourths of the coal mined in 1913 came from that section. The larger part of an area embracing Craig, Rogers, Tulsa, Wagoner, Okmulgee, Muskogee, McIntosh, Haskell, Sequoyah, Le Flore, Coal, Latimer, and Pittsburg counties, all in the eastern part of the State, is known to contain coal.

CHARACTER OF COAL BEDS.

There are seven coal beds in this field that are thick enough to be worked on a commercial scale. There are, however, two groups of beds from which most of the coal mined in the southern part of the field has been obtained. These are the Hartshorne coal beds, generally two in number, at the top of the Hartshorne sandstone, and the two McAlester coal beds near the top of the McAlester shale, and from 1,500 to 1,800 feet above the Hartshorne group. The Hartshorne beds are in places about 50 feet apart, and in other places they meet. West of Wilburton the upper bed is absent. The lower bed is 4 to 5 feet thick and the upper one is about 4½ feet thick. East

of Wilburton there are two beds about 2½ feet thick in the McAlester group; but about Hartshorne, McAlester, and Savanna there is only one bed, which ranges in thickness from 3 to 5 feet.

The Henryetta field in Okmulgee county was recently opened. It contains a bed of coal averaging 3 feet in thickness, and lying practically horizontal at depths varying from 100 to 200 feet, and is worked mostly by machines. The coal is not as good as other Oklahoma coals but serves as a good steam and railroad fuel, and can be produced more cheaply than the other coals to the south of Okmulgee County. Two important mining towns, Henryetta and Dewar, have recently been built as a result of the development of this coal field. The Henryetta coal field, unlike the southern coal fields, is not on segregated lands. The coal beds in Pittsburg, Coal, Latimer, and Le Flore counties and part of Haskell County, are on segregated coal lands belonging to the Choctaw and Chickasaw Indian Nations.

MINING METHODS.

The earliest records of coal production in Oklahoma are for 1880, when 120,947 tons of coal was produced. The production in 1913 was 4,165,770 tons. About 60 per cent of the mines are opened by slopes and drifts with lengths on the incline varying from 50 to 3,500 feet. The shaft mines number about one-third of the mines in the State, and vary in depth from 70 to 800 feet. The coal is mined entirely by the room-and-pillar method. Some of the mines are quite gaseous, and much dust is produced in mining.

In 1896 there were 56 mining machines in operation, which produced 14 per cent of the coal mined in the State. In 1898, there were 75, which produced 19.9 per cent of the coal. The use of mining machines gradually declined until in 1907 there were only 11 machines in operation, producing less than 1 per cent. Since that date, the number of machines has gradually increased until in 1913, there were 103 machines in operation, producing 16.1 per cent of the coal.

Shooting off the solid is practiced to such an extent in Oklahoma that in 1912, 86.4 per cent of the coal was thus produced. This proportion, however, was by the increase of machines in 1913 reduced to 80.9 per cent. The laws of the State compel the payment of wages on the basis of run-of-mine, hence a tendency to encourage the practice of shooting from the solid. Holes are usually drilled 6 to 10 feet deep, and sometimes as much as 14 feet with no undercutting nor channeling. Sufficient powder is charged to break the coal with the result that much fine coal is produced. In some instances

these long holes are charged with dynamite. Dust is scattered throughout the mine, the roof is loosened more or less, and at least 15 per cent of the coal shot down is thrown into the gob and lost. This method of mining produces unsafe conditions in the mine in addition to being wasteful, as much of the coal is so badly crushed that it is unfit for commercial uses.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

The act of Congress establishing a mine-inspection service in all Territories where the output of coal exceeded 1,000 tons annually was approved March 3, 1891. Under this act the first inspector in Indian Territory (now Oklahoma) entered on duty March 20, 1893. Mine operators were required to report to the inspector all cases of fatal accidents at their mines, such report to be in writing and made within 10 days after such death occurred. Annual reports for fiscal years ending June 30 were rendered to the Secretary of the Interior.

A State department of mines and mining was created by an act approved April 6, 1908, and under the provisions of this law the appointment of a chief mine inspector and three district inspectors was authorized, the inspectors to investigate all accidents, injuries, and deaths at mines. The first report of the State inspector covers the period from November 16, 1907, to October 31, 1908, and annual reports since the latter date have been issued for fiscal years ending October 31.

It has been the practice of mine operators to report to the inspector all fatal and serious accidents. Since the enactment of the compensation law, all accidents causing a disability of one day or more are reported. All accidents reported are included in the inspector's annual reports and are classified as fatal or nonfatal, but no distinction is made between serious and slight injuries.

In 1915 the inspection force consisted of one chief inspector and three deputy inspectors.

ACCIDENTS.

Tables 120 and 121 show the production of coal, number of men employed, and the number of fatalities in and about the coal mines of Oklahoma. The fatalities as tabulated have been compiled from the Territorial and State mine inspectors' records, and are complete from 1893 to and including 1913. During this period of 21 years, there were 729 fatalities representing a rate of 5.45 per 1,000 men employed.

FATALITIES IN OKLAHOMA COAL MINES, BY PRINCIPAL CAUSES, DURING THE YEARS 1893 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	153	20.99	1.14
Mine cars and locomotives	78	10.70	.58
Gas and dust explosions	262	35.94	1.96
Explosives	115	15.77	.86
Miscellaneous	79	10.84	.59
Shaft	25	3.43	.19
Surface	17	2.33	.13
Total, 21 years	729	100.00	5.45

COAL-MINE ACCIDENTS IN OKLAHOMA IN WHICH 5 OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Nature of accident.	Number killed.
1892 Jan. 7	No. 11	Krebs	Mine explosion	100
1897 Jan. 4	No. 1	Alderson	do	5
1901 Apr. 29	McAlester No. 5	do	Blown-out or windy shot.	6
1901 Dec. 28	No. 1	Hartshorne	Fell from cage	6
1902 Jan. 13	Milby and Dow	Dow	Mine fire	10
1903 Apr. 12	Central Slope 77	Carbon	Mine explosion	6
1905 Apr. 30	No. 19	Wilburton	do	13
1906 Jan. 24	Poteau No. 6	Witteville	Dynamite explosion	14
1908 Aug. 26	Hailey-Ola No. 1	Haileyville	Mine fire	29
1909 Oct. 21	Rock Island No. 8	Hartshorne	Mine explosion	10
1910 Mar. 31	Great Western No. 2	Wilburton	do	6
1912 Feb. 22	Western No. 5	Lehigh	Mine fire	9
1912 Mar. 20	San Bois No. 2	McCurtain	Mine explosion	73
1914 Sept. 4	No. 1	Adamson	Cave-in	13

The amount of coal produced per fatality during this period was 71,111 tons, or there were 14.06 fatalities per million tons mined. Of the total number of fatalities during this period 35.94 per cent was due to gas and dust explosions, 20.99 to falls of roof and coal, and 15.77 per cent to explosives. Mine cars and locomotives claim 10.70 per cent of the fatalities. Since the beginning of inspection service March 20, 1893, to and including 1913, there were 12 mine disasters in which 5 or more men were killed at one time, as shown in the accompanying list.

Since 1903, the majority of the employees at the coal mines in Oklahoma have been on an 8-hour basis. Fatalities have, therefore, been calculated on the basis of a 2,000-hour year, showing that the rate for Oklahoma on this basis is 6.81 for the period of 1903 to 1913, except 1909. This compares with 5.08 based on the number of actual employees for the same period. The number of hours worked per year per man is 1,406, as compared with 1,564 for Kansas, and 2,132 for West Virginia. The Oklahoma rate based on the actual number

NUMBER OF HOURS TO THE WORKING DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN OKLAHOMA.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, and 10 hours per day.	Total number of men employed.
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	55	6,952	3	487	2	190	75	7,704
1904	59	8,251	2	95	2	75	66	8,487
1905	59	7,544	.....	.....	3	108	60	7,712
1906	70	7,824	3	167	4	81	179	8,251
1907	83	8,079	.....	.....	6	194	125	8,398
1908	64	8,258	.....	.....	4	118	275	8,651
1909[b]	.....	.....	.....	.....	.....	.....	.....	8,689
1910	89	8,472	.....	.....	2	50	135	8,657
1911	90	8,247	.....	.....	3	35	447	8,729
1912	82	8,105	.....	.....	3	120	560	8,785
1913	87	8,725	.....	.....	2	109	210	9,044

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN OKLAHOMA AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day (all employees).	Total hours per year.	Number of 2,000-hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	247	62,574	15,455,778	7,727	42	5.44
1904	199	68,207	13,573,193	6,786	29	4.27
1905	188	61,972	11,650,736	5,825	41	7.04
1906	166	66,516	11,041,656	5,521	44	7.97
1907	216	67,697	14,622,552	7,311	39	5.33
1908	172	69,719	11,991,668	5,996	46	7.67
1909[a]	.....	.....	.....	.....	.....	.....
1910	144	69,491	10,006,704	5,003	39	7.80
1911	156	70,349	10,974,444	5,487	27	4.92
1912	174	71,080	12,367,920	6,184	99	16.01
1913	197	72,780	14,337,660	7,169	23	3.21

[a] Census year.

of employees appears to be slightly less than the fatality rate in West Virginia, but when reduced to the uniform basis of fatalities per 2,000-hour workers, the rate becomes 6.81 for Oklahoma, as compared with 5.18 for West Virginia. For comparative purposes, Tables 40 and 41 have been compiled so that it is an easy matter to compare Oklahoma with other States. The tables of statistics for the State of Oklahoma follow:

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN OKLAHOMA.[a]

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899	1,825	281,256	154	1907	669	17,092	26
1900	110	31,100	283	1908	6,929	398,251	57
1901	.....	.....	.....	1909	1,576	11,368	7
1902	150	9,000	60	1910	8,213	1,247,828	152
1903	448	1,928	4	1911	444	15,106	34
1904	488	5,175	11	1912	860	12,109	14
1905	397	3,509	9	1913	1,696	135,274	80
1906	7,372	535,504	72	1914	1,286	39,500	31

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 120.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN OKLAHOMA, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.[a]

[Figures for total production and all items below horizontal lines in various columns selected from Mineral Resources, U. S. Geol. Survey. Figures in column 4 compiled from Territorial and State mine inspectors' reports. Figures in columns 5, 6, and 7 and averages in colums 9 and 10 prior to 1900 calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial axe or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1880–1887	2,966,438																				
1888	761,986	1.88	1,700						448												
1889	752,832	1.76	1,862					(b)	404												
1890	869,229	1.82	2,571					238	338	1.42											
1891	1,091,032	1.74	2,891					222	377	1.70											
1892	1,192,721	1.71	3,257	c 100				211	366	1.73											
1893	1,252,110	1.79	3,446	6	1.74	4.79	208,685	171	363	2.12											
1894	969,606	1.59	3,101	9	2.90	9.28	107,734	157	313	1.99											
1895	1,211,185	1.43	3,212	9	2.80	7.43	134,576	164	377	2.30											
1896	1,366,646	1.40	3,549	15	4.23	10.98	91,110	170	385	2.26		14.0								56	
1897	1,336,380	1.34	3,168	28	8.84	20.95	47,728	176	422	2.40		19.7								54	
1898	1,381,466	1.32	3,216	23	7.15	16.65	60,064	198	430	2.17		19.9								75	
1899	1,537,427	1.43	4,084	28	6.86	18.21	54,908	212	376	1.77		18.0			52	16	6			74	
1900	1,922,298	1.45	4,525	35	7.73	18.21	54,923	228	425	1.86		12.5								58	
1901	2,421,781	1.62	6,706	57	8.50	23.54	42,487	208	361	1.74		7.3								47	
1902	2,820,666	1.51	5,574	42	7.53	14.89	67,159	232	506	2.18		4.2								23	
1903	3,517,388	1.82	7,704	42	5.45	11.94	83,747	247	457	1.85		2.1			16	18	2			36	
1904	3,046,539	1.82	8,487	29	3.42	9.52	105,053	199	359	1.80		1.4			8	10				18	
1905	2,924,427	1.76	7,712	41	5.32	14.02	71,327	188	379	2.02		1.4			25	4				29	
1906	2,860,205	1.92	8,251	44	5.33	15.38	65,005	166	347	2.09		1.2			18	11				29	
1907	3,642,658	2.04	8,398	39	4.64	10.71	93,401	216	434	2.01		.7			7	3	1			11	
1908	2,948,116	2.03	8,651	46	5.32	15.60	64,089	172	341	1.98		1.1			15	2				17	

1909	3,119,377	2.00	8,689	48	5.52	15.39	64,987	(b)	359	(b)	.....	1.5	.....	.....	28	4	2	.....	.....	34	99
1910	2,646,226	2.22	8,657	39	4.51	14.74	67,852	144	306	2.13	.....	1.1	.....	.....	12	.....	1	.....	.....	13	98
1911	3,074,243	2.05	8,729	27	3.09	8.78	113,861	156	352	2.26	5.5	2.8	78.8	12.9	5	6	5	2	8	26	112
1912	3,675,418	2.14	8,735	99	11.27	26.94	37,125	174	418	2.40	1.3	7.1	86.4	5.2	16	14	4	15	11	60	101
1913	4,165,770	2.05	9,044	23	2.54	5.52	181,120	197	461	2.34	2.2	16.1	80.9	.8	35	13	.....	45	10	103	95
Total	59,474,164	.....	.....	829	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (1893–1913)	2,468,568	.....	6,386	34.71	5.45	14.06	71,111	191	333	2.03	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	3,968,613	2.06	8,078	31	3.84	7.77	128,665	205	494	2.41	2.0	26.4	70.7	.9	29	8	20	57	2	116	9

[a] Oklahoma became a State in 1908. Figures for years previous refer to Indian Territory. [b] Not reported. [c] Figures in italics represent incomplete fatality records.

TABLE 121.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN OKLAHOMA, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE DURING THE CALENDAR YEARS 1893 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1893	2	1	1	1	.....	1	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
1894	3	.....	2	1	.....	2	.....	.....	.....	.....	.....	.....	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	9
1895	2	.....	2	4	.....	1	.....	.....	.....	.....	.....	.....	9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9
1896	6	1	2	4	.....	2	.....	.....	.....	.....	.....	.....	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15
1897	6	1	3	2	5	4	.....	.....	1	.....	2	.....	24	1	.....	2	.....	3	.....	.....	.....	1	.....	.....	1	28
1898	4	1	4	4	5	4	.....	1	.....	.....	.....	.....	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	23
1899	7	2	2	4	.....	9	.....	2	.....	.....	.....	.....	26	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	2	28
1900	9	1	2	11	5	4	.....	1	.....	.....	.....	.....	33	.....	2	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	35
1901	12	.....	7	8	12	6	.....	1	.....	.....	.....	.....	46	2	.....	8	.....	10	.....	.....	.....	.....	1	.....	1	57
1902	10	.....	8	4	2	5	.....	1	.....	.....	10	.....	40	.....	.....	.....	.....	.....	1	.....	1	.....	.....	.....	2	42
1903	10	.....	3	13	4	9	.....	.....	1	.....	.....	.....	40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	2	42
1904	4	.....	7	3	10	3	.....	.....	.....	.....	.....	.....	27	.....	1	1	.....	2	.....	.....	.....	.....	.....	.....	.....	29
1905	6	1	3	18	3	8	1	.....	.....	.....	.....	.....	40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	41
1906	7	.....	4	6	8	17	.....	.....	.....	.....	.....	.....	42	1	.....	.....	.....	1	1	.....	.....	.....	.....	.....	1	44
1907	15	2	2	4	3	12	.....	1	.....	.....	.....	.....	39	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	39
1908	3	.....	3	2	2	1	1	.....	.....	.....	29	4	45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	46
1909	6	.....	6	15	4	10	.....	.....	.....	.....	.....	6	47	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	47
1910	11	.....	3	.....	13	3	.....	.....	.....	.....	.....	1	31	.....	.....	2	3	5	.....	.....	1	.....	.....	2	3	39
1911	6	.....	5	1	1	9	.....	1	.....	.....	2	.....	25	.....	.....	1	.....	1	.....	.....	.....	.....	.....	1	1	27
1912	6	1	3	75	2	1	.....	.....	.....	.....	11	.....	99	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	99
1913	7	.....	6	2	1	4	.....	2	.....	.....	.....	.....	22	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	23
1914	20	.....	8	1	1	2	.....	8	.....	.....	.....	1	31	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	31

OREGON.

AREA AND DISTRIBUTION OF COAL FIELDS.

The coal in Oregon is subbituminous. The Coos Bay field, which is the principal one in the State, occupies a small structural basin in the vicinity of Coos Bay and contains 230 square miles. It extends north and south and is about 30 miles long, with a maximum width of 11 miles. There are other coal fields in the State, but none of them has been worked to any extent, so do not enter into the question of mine accidents. The Coos Bay field may be divided into six parts, consisting of four basins and two arches. The basins containing workable coal are the Newport, Beaver Slough, Coquille, and South Slough. The arches contain no coal. The structure of these basins may be considered as simple, the dip being slight. There are a number of faults, but these are of little importance.

The Newport basin, the principal one that has been worked, contains about 6 feet of coal in three benches, yielding 5 feet of coal that can be mined. The roof is sandstone and requires comparatively little timbering. The top bench of coal is usually left with the upper parting to form the roof.

The Beaver Slough basin contains five beds, the most important being the lowest one, which contains over 6 feet of coal. This bed has been mined at Beaver Hill.

MINING METHODS.

The first records of coal production for Oregon are for the year 1880, when 43,205 tons was reported. Three mines have been opened by drifts and slopes in the Newport basin, and the coal is mined by the room-and-pillar method. In the Beaver Slough basin one or two mines have been opened by slopes and a small amount of coal has been mined by the pillar-and-chute system.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

No provision has been made by the State of Oregon whereby accidents in or about coal mines shall be reported to a State official. The coal production of the State since 1880 has averaged less than 64,000 tons annually. Reports of accidents have, since 1910, been voluntarily rendered to the Federal Bureau of Mines by the mine operators at the close of each calendar year.

ACCIDENTS.

The production of coal, number of men employed, and the number of fatalities, as far as complete records are available, are given in Tables 122 and 123. The fatalities at coal mines have been recorded

only since 1909, but the number of employees has been reported since 1890. For the five years for which continuous records are available, the accident rate in Oregon is comparatively low, being 2.69 per 1,000 men employed, but on the tonnage basis it is high, being 10.37 fatalities per million tons mined. There have been no serious coal-mine disasters in Oregon. The tables of statistics for the State follow:

FATALITIES IN OREGON COAL MINES, BY PRINCIPAL CAUSES, DURING THE YEAR 1909 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	1	33.00	0.90
Mine cars and locomotives	2	67.00	1.79
Gas and dust explosions			
Explosives			
Miscellaneous			
Shaft			
Surface			
Total, 5 years	3	100.00	2.69

STRIKES AND LOCKOUTS.

During 1914, the first year in which there were labor troubles in Oregon, 21 men were on strike, resulting in the loss of 798 days, or an average of 38 days per man.

TABLE 122.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN OREGON, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.

[Figures for total production and columns 2, 3, and 8 compiled from Mineral Resources, U. S. Geol. Survey. Figures in column 4 reported direct to the Bureau of Mines by the operators. Figures in columns 5, 6, 7, 9, and 10 calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial axe or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1880–1889	468,860																				
1890	61,514	2.89	208					305	296	0.97											
1891	51,826	3.00	100					125	518	4.14											
1892	34,661	4.29	90					120	385	3.21											
1893	41,683	3.57	110					192	379	1.97											
1894	47,521	3.87	88					243	540	2.22											
1895	73,685	3.36	414					69	178	2.58											
1896	101,721	2.90	254					191	400	2.09											
1897	107,289	3.09	254					171	422	2.47											
1898	58,184	3.65	199					142	292	2.06											
1899	86,888	3.00	124					238	701	2.95											
1900	58,864	3.74	141					273	417	1.53											
1901	69,011	2.52	187					228	369	1.62											
1902	65,648	2.44	265					234	248	1.06											
1903	91,144	2.43	235					258	388	1.50											
1904	111,540	2.18	334					149	334	2.24											
1905	109,641	2.58	316					242	347	1.43											
1906	79,731	2.66	209					224	381	1.70											
1907	70,981	2.34	184					231	386	1.67											
1908	86,259	2.74	214					249	403	1.62											
1909	87,276	2.69	235	1	4.26	11.46	87,276	(a)	371	(a)											10
1910	67,533	3.48	153	0				257	441	1.72											11
1911	46,661	2.32	304	1	3.29	21.43	46,661	179	153	.85											9
1912	41,637	2.60	222	1	4.50	24.02	41,637	239	188	.79											9
1913	46,063	2.53	203	0				283	227	.80											7
Total	2,165,821			3																	
Average (1909–1913)	57,834		223	0.6	2.69	10.37	86,390	232	250	1.12											
1914	51,558	2.78	190	1	5.26	19.40	51,558	266	271	1.02											3

a Not reported.

TABLE 123.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN OREGON, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE, DURING THE CALENDAR YEARS 1909 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	1	2	3	4	5	6	7	8	9	10	11	12	Total.	13	14	15	16	Total.	17	18	19	20	21	22	Total.	
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
1909					1								1													1
1910																										
1911		1											1													1
1912				1									1													1
1913																										
1914				1									1													1

PENNSYLVANIA (ANTHRACITE).

AREA AND DISTRIBUTION OF COAL FIELDS.

The anthracite coal fields of Pennsylvania occupy portions of Sullivan, Lackawanna, Luzerne, Carbon, Schuylkill, Dauphin, and Northumberland and Columbia counties in the northeastern part of the State. They comprise an area of 480 square miles, and form four distinct fields, as follows: The northern or Wyoming-Lackawanna field, in Luzerne and Lackawanna counties; eastern-middle or Lehigh field, in Luzerne and Carbon counties; southern or Schuylkill field, in Dauphin and Schuylkill counties; and western-middle field. A brief description of each field is given in the following paragraphs:

CHARACTER OF COAL BEDS.

The coal beds of the anthracite fields of Pennsylvania are described by Stoek [a] as follows:

NORTHERN FIELD.

From Forest City to Pittston and from Pittson to Nanticoke, north of the Susquehanna, the maximum dips are 10° to 20°, while between Pittston and Nanticoke, south of the Susquehanna, steeper dips, ranging from 60° to 70°, are found, and near Glen Lyon the measures are overturned and badly broken. There are numeous anticlines and synclines in the measures which can sometimes be traced on the surface, the synclines being often marked by ridges and the anticlines by valleys.

A marked feature of the northern field is the buried valley of the Susquehanna, extending from Pittston to Nanticoke. This is the bed of a former glacial stream which has cut down into the coal measures in places, thus cutting out large areas of the upper coal beds. The valley is now filled with sand, and there are numerous pot holes in it, which add an element of uncertainty and danger to the mining.

The Wyoming-Lackawanna basin is deepest (2,200 feet) midway between Wilkes-Barre and Nanticoke. About 4 miles above Pittston, near Lackawanna station, only 100 to 150 feet of the coal measures are left, but northeast from here, several miles above Scranton, the coal measures sink again to a depth of 700 feet, and then rise and spoon out beyond Forest City.

It is difficult to state the number of workable beds, as beds are now being worked in the upper end of the Lackawanna Valley which a very few years ago were neglected and considered unworkable. The splitting of a large coal bed into several smaller beds, which divide and are sometimes separated by as much as 200 feet of rock, renders it impossible to correlate beds in different parts of the field until continuous sections can be made by means of actual mine workings. As the result of measurements of 891 sections by the second geological survey of Pennsylvania, 81.8 per cent of the total coal in the Wyoming basin is or may be considered marketable coal, the remaining 18.2 per cent being interbedded slate, shale, and other refuse. The deposits in this section are particularly free from refuse, and the comparative freedom of this section from plication and folding gives a high percentage of marketable coal.

EASTERN-MIDDLE FIELD.

The structure of the eastern-middle field is simple, consisting of a succession of anticlines, usually with broad flat crests and shallow intervening basins only about

[a] H. H. Stoek, The Pennsylvania anthracite coal fields: 22d annual rept., 1900–1901, U. S. Geol. Survey, 1901, p. 69.

500 to 600 feet deep, the sides dipping 10° to 40°. This gives a large extent of outcrop, and the comparative shallowness of the basins has been very favorable to mining, so that the field has been extensively developed and its structure quite thoroughly determined. The Mammoth, Buck Mountain, Primrose, Parlor, Portland, and Gamma beds vary in thickness in different localities. The second geological survey of Pennsylvania estimated that from 75 to 77 per cent of the total thickness of coal was marketable.

SOUTHERN FIELD.

The southern field consists of a number of connected basins which grow gradually deeper from north to south, culminating along the foot of Sharp Mountain in very deep, highly upturned, and greatly contorted measures. The Pottsville conglomerate in this region is very thick, ranging from 1,100 to 1,475 feet. It is made up of coarse materials, and contains a number of valuable coal beds, especially at the western end. At the point where the main field subdivides into the two westwardly extending basins there are 6 Lykens Valley beds in the conglomerate, each 3 to 10 feet thick. The coal measures proper are at least 2,500 feet thick, and 20 different coal beds have been worked. From measurements of 275 sections the second geological survey estimated 72 per cent of the coal as marketable.

WESTERN-MIDDLE FIELD.

In the western-middle field the beds incline steeply, the average dip being 35 to 40 degrees. There has been much folding, sliding, and shifting of strata, which has crushed the coal in many places and mixed with it slate and bony coal partings. The coal measures are 1,200 feet thick, and contain from 10 to 12 different beds, many of them of great thickness and with comparatively small intervening barren intervals. The Lykens Valley beds are also found in the conglomerate, or No. 12, and toward the western end of the field these beds are mined; 1,144 sections throughout the field give 23 per cent of refuse in the coal, but it is not safe to estimate more than 75 per cent of the original deposit as marketable coal.

Fire damp is found in many of the deeper mines, particularly in the Wyoming region and in the western end of the Schuykill region. In a number of mines it is present in such quantities that the use of safety lamps is absolutely necessary.

MINING METHODS.

In each of the anthracite fields there are a number of places where the coal outcrops near the surface, and where conditions are favorable for mining the coal by open-pit methods. The overburden is stripped by hand labor, steam shovel, or wire-rope tramway and the coal quarried out and hauled by incline to the surface, or if the stripping pit communicates with the underground workings the coal may be taken through underground haulage ways to the bottom of the shaft or slope and then hoisted to the surface.

Most of the mines are shaft and slope mines, the slopes being driven in the coal from the outcrop, and the shafts being always vertical and usually so placed as to cut the coal at the lowest possible elevation on the property in question. The room-and-piller system is the one usually used for underground mining, but owing to the deposits being

steeply inclined and more or less irregular, the system has to be adapted to meet local conditions in mining the various beds. It is impossible to carry out a typical room-and-pillar system, as in the flat bituminous coal beds. The details of the system under different mining conditions vary so widely that a comparison of mining methods from different districts or localities gives the impression that the coal is mined by several systems having nothing in common. On close inspection, however, the fact is disclosed that they all have three features which are identical:[a] (1) The breasts, or rooms, or working places are all long and comparatively narrow; (2) they are driven nearly parallel to each other; and (3) they are separated by long narrow pillars of coal, broken only by small openings for ventilation.

These three features, which are common to all anthracite workings in Pennsylvania, are the identifying characteristics of the "pillar-and-breast," "pillar-and-room," "post-and-stall," "stoop-and-room," or "bord-and-pillar" system. The geologic peculiarities of the anthracite coal beds explain why the mining methods differ so radically in detail from those employed in other beds. Coal beds ranging from 3 or 4 feet up to 70 feet in thickness are worked on dips varying from horizontal to vertical.

From the bottom of the shaft or slope a gangway and a parallel airway are driven in opposite directions from the shaft or slope and along the strike of the bed. From these gangways rooms or breasts are turned either at right angles or obliquely, the angle of turning being dependent upon the dip of the seam.

"Flat workings" is a term applied to those coal beds which vary from horizontal to a dip of about 25°. When the coal bed is flat, it is usually opened by a shaft sunk through the overlying measures. Gangways are driven from the bottom of the shaft, and when they have reached a sufficient distance to permit a thick pillar of coal being left to protect the shaft, breasts are opened from the upper side of each gangway.

Where the inclination is more than 30°, the coal will slide without the use of sheet-iron chutes, and it then becomes necessary to stop up the lower end by a battery, built of logs or heavy planks. This acts as a support for the broken coal and allows the breast to fill to the face with coal, thus giving the miners a broken-coal platform on which to stand while working.

The battery workings may be divided into two general classes: (1) Where the coal is stored in the breast and the rock and refuse taken out through a chute, and (2) where the rock is stored in a breast and the coal taken out through chutes. Details of the various modifications of these systems are given fully by Chance.[b]

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[a] Chance, H. M., Mining methods and appliances used in the anthracite coal fields: Second Geol. Survey of Pennsylvania, 1883, p. 129.

[b] Chance, H. M., loc. cit.

In the anthracite mines rotary drills are used and the coal is broken by the use of black powder. Dynamite or giant powder is used largely for rock work and sometimes for driving gangways in coal. Dynamite shatters the coal so badly that it is not used extensively for the mining of coal. The coal is not undercut as a general rule, and it is only recently that special mining machines have been developed for the anthracite field.

Table 50 shows the amount of explosives used in the anthracite fields from 1899 to 1913. It will be noted that the increase in the amount of dynamite used has been about fivefold since 1899, whereas the amount of black powder used has increased only about one-third. In 1909 permissible explosives were introduced into the anthracite mines and in five years the quantity used has increased from 666,807 pounds to 3,323,645 pounds in 1913. The fatalities due to the use of explosives in the anthracite mines are given in Table 49.

Every known form of haulage is to be found in the anthracite mines; the main ones are indicated in Table 54. The number of horses and mules used in the mines has remained practically the same since 1898, averaging about 15,000 per year. The number of steam locomotives used has almost doubled, whereas the number of electric locomotives has increased from 24 in 1898 to 781 in 1913. The number of compressed-air locomotives has increased from 10 in 1898 to 161 in 1913. Cars are usually gathered from the rooms by mules except where the grade is sufficient to run the cars out by gravity. The cars vary in size from 70 to 140 cubic feet and in capacity from 1¾ to 4 tons. They are usually built of wood with iron bands, although steel cars have been introduced in recent years.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

The official inspection of coal mines in Pennsylvania was established by an act approved April 12, 1869, applicable only to anthracite mines in Schuykill County. The appointment of the inspector was vested in the governor, and the inspector was required to investigate the cause of every accident resulting in death or serious injury. Mine operators were required to report to the inspector within 24 hours all accidents resulting in death or personal injury. The inspector rendered annual reports to the governor and enumerated therein all accidents in and about the mines.

An act approved March 3, 1870, terminated the services of the inspector appointed under the act of April 12, 1869, and authorized the governor to appoint, upon the recommendation of the examining boards, six mine inspectors—three for the counties of Luzerne (including what is now Lackawanna County) and Carbon and three for the counties of Schuylkill, Dauphin, Northumberland, and Columbia.

Annual reports, in which all accidents were enumerated, were rendered to the governor. An act approved April 5, 1870, divided the inspection counties into two districts and authorized the appointment for each district of a clerk, to whom the inspectors were required to render monthly reports of deaths and injuries.

On May 9, 1871, an act was approved requiring coal companies in counties where there was no inspector to furnish a report of all accidents to the auditor general, who was required to publish an annual report and state therein the causes of such accidents. The auditor's report was published under the title of "Mineral Statistics of Pennsylvania." The act of April 25, 1873, transferred the authority to appoint the mine inspectors from the governor to a majority of the board of examiners provided for by the act of March 3, 1870, but the appointive power was again vested in the governor by an act approved May 18, 1878. On June 30, 1885, an act was approved applicable to all anthracite mines employing more than 10 men. The anthracite counties were divided into seven districts and the inspectors were required to render annual reports to the secretary of internal affairs. The number of inspection districts was increased to eight by an act approved June 2, 1891. An act of July 15, 1897, made it unlawful to employ as a miner any person not holding a certificate of competency from the miners' examining board established by the act. An act of July 15, 1897, established a bureau of mines in the department of internal affairs.

An act approved June 8, 1901, effective January 1, 1902, changed the manner of selecting the mine inspectors by making the office elective instead of appointive. The number of elective districts was reduced to 6, but the number of inspectors was increased to 15. It was provided that the inspectors should be elected from among a list of eligibles certified to the secretary of state by the examining board. The inspectors so elected rendered monthly reports to the chief of the Bureau of Mines and also rendered annual reports to the secretary of internal affairs.

An act of April 14, 1903, established the department of mines.

On May 3, 1905, an act was approved increasing the number of districts to 7, and the number of inspectors to 20, and requiring the inspectors to make annual reports to the chief of the department of mines. An act of May 5, 1911, provided for 8 elective districts and 21 inspectors, and an act of June 1, 1915, increased the number of anthracite inspectors to 25.

Under the inspection laws, it is the practice of the operators to report to the district inspectors all injuries causing disability for 6 days or more. The district inspectors, in their reports to the department of mines, omit accidents of a less serious nature, so that only the more serious injuries are published in the annual report of the

department of mines. The department has not officially defined a serious injury, and it is left to the descretion of each district inspector as to which of the accidents reported to him by mine operators may be eliminated from his report to the department.

ACCIDENTS.

Tables 124 and 125 show the total number of men employed and the number of men killed from the beginning of inspection service in 1870 to date. During the period 1870 to 1913, inclusive, 17,716 fatalities occurred in and about the anthracite mines, representing a rate of 3.42 per 1,000 men employed. The amount of coal mined per fatality was 124,968 tons, or there were 8 fatalities per million tons mined.

Table 125 shows the number of fatalities by causes, in conformity with the latest reports of the State mine inspector and so adapted as to conform with the standard form used by the Bureau of Mines. This classification gives much more detail than is ordinarily available, and it is believed will be of material assistance to operators, inspectors, and others, who are making a study of mine accidents, their causes, and their prevention.

Of the total number of fatalities that have occurred during this period, 41.65 per cent was due to falls of roof and coal; 13.56 per cent to mine cars and locomotives; 10.10 per cent to explosives; and 7.59 per cent to explosions of gas. The percentage of fatalities due to explosives in the anthracite mines is practically 5 times that in the Pennsylvania bituminous fields, given in tables relating thereto, whereas the rate per 1,000 men employed is 7 times as high as it is in the bituminous fields of the State.

Since 1869 to the end of 1914 there have been in the anthracite field 80 accidents in each of which 5 or more men have been killed at one time. A complete list of these disasters is shown in the accompanying table.

FATALITIES IN PENNSYLVANIA ANTHRACITE COAL MINES, BY PRINCIPAL CAUSES DURING THE YEARS 1870 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	7,378	41.65	1.42
Mine cars and locomotives	2,403	13.56	.46
Gas explosions	1,344	7.59	.26
Explosives	1,790	10.10	.35
Miscellaneous	1,637	9.24	.32
Shaft	843	4.76	.16
Surface	2,321	13.10	.45
Total, 44 years	17,716	100.00	3.42

ACCIDENTS IN PENNSYLVANIA ANTHRACITE MINES IN WHICH 5 OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Nature of accident.	Killed.
1847 Feb. —	Spencer	Pottsville	Mine explosion	7
1869 Sept. 6	Avondale	Plymouth	Mine fire	179
1870 Mar. 22	Potts	Potts mine	Explosion of breaker boilers.	5
1870 Aug. 10	Heins & Glassmire	Middleport	Cage fell down shaft	9
1870 Aug. 29	Preston No. 3	Girardville	Fell down slope	7
1871 May 27	West Pittston	West Pittston	Smoke from burning breaker.	20
1871 Oct. 2	Otto Red Ash	Branch Dale	Mine explosion	5
1873 June 10	Henry Clay	Shamokin	....do	10
1877 May 9	Wadesville	Wadesville	....do	7
1878 Jan. 15	Potts	Locust Dale	....do	5
1879 May 6	Audenried	Audenried	Mine fire	6
1880 May 3	Lykens Valley	Shamokin	Mine explosion	5
1882 May 24	Kohinoor	Shenandoah	....do	5
1884 Aug. 21	Buck Ridge	Shamokin	Mine fire	7
1885 Apr. 6	Cuyler	Raven Run	Fall of roof	10
1885 Aug. 11	West End	Mocanaqua	Gas from boiler fires in mine.	10
1885 Oct. 21	Plymouth No. 2	Plymouth	Mine explosion	6
1885 Dec. 18	Nanticoke No. 1	Nanticoke	Buried by inrush of quicksand.	26
1886 Aug. 30	Fair Lawn	Scranton	Mine explosion	6
1886 Sept. 13	Marvine	....do	Suffocated by inrush of mine gas.	8
1886 Nov. 26	Conyngham	Wilkes-Barre	Mine explosion	12
1887 Apr. 27	Tunnel	Ashland	Suffocated by inrush of mine gas.	5
1889 May 9	Kaska William	Middleport	Mine car fell on men in cage.	10
1890 Feb. 1	Nottingham	Plymouth	Mine explosion	8
1890 Mar. 3	Shaft No. 3	South Wilkes-Barre	....do	8
1890 Apr. 2	Susquehanna No. 4	Nanticoke	....do	5
1890 May 15	Jersey No. 8	Ashley	....do	26
1891 Feb. 4	Spring Mountain No. 1	Jeanesville	Drowned by inrush of water from abandoned workings and asphyxiated by gas from fire built by imprisoned men.	13
1891 Oct. 23	Richardson	Glencarbon	Imprisoned by rush of coal and suffocated by mine gas.	7
1891 Nov. 8	Susquehanna No. 1	Nanticoke	Mine explosion	12
1892 Apr. 20	Lytle	Minersville	Drowned by water from old workings.	10
1892 July 23	York Farm	Pottsville	Mine explosion	15
1893 Apr. 1	Neilson	Shamokin	Mine fire	10
1893 June 22	Susquehanna No. 1	Nanticoke	Mine explosion	5
1893 Sept. 21	Lance No. 11	Plymouth	....do	6
1894 Feb. 13	Gaylord	....do	Fall of roof	13
1894 July 17	East Sugar Loaf	Stockton	Dynamite explosion	8
1894 Oct. 8	Luke Fidler	Shamokin	Mine fire	5
1894 Oct. 11	Henry Clay	....do	Boiler explosion	6
1895 Feb. 18	West Bear Ridge	Mahanoy Plane	Mine explosion	5
1895 Oct. 7	Dorrance	Wilkes-Barre	....do	7
1896 June 28	Twin	Pittston	Fall of roof	58
1896 Oct. 29	Shaft No. 3	South Wilkes-Barre	Mine explosion	6
1897 Jan. 13	Wadesville	Wadesville	Crosshead fell down shaft.	5
1897 Sept. 28	Jermyn No. 1	Rendham	Mine fire	5
1897 Oct. 30	Von Storch	Scranton	....do	6
1898 May 26	Kaska William	Middleport	Drowned by water from old workings.	6
1898 Oct. 1	Midvale	Wilkes-Barre	Mine fire	5
1898 Nov. 5	Exeter	West Pittston	Mine car fell on men in cage.	9
1900 Nov. 9	Buck Mountain	Mahanoy	Mine explosion	7
1901 Oct. 25	Buttonwood	Plymouth	....do	6
1902 Nov. 29	Luke Fidler	Shamokin	....do	7
1902 Dec. 9	South Wilkes-Barre	South Wilkes-Barre	Dynamite explosion	5
1904 Jan. 30	Maple Hill	Mahanoy City	....do	5
1904 May 5	Lance	Plymouth	....do	5
1904 May 5	Locust Gap	Locust Gap	Mine fire	5
1904 May 25	Williamstown	Williamstown	Suffocated by gases from locomotive.	10
1904 Nov. 2	Auchincloss	Nanticoke	Fell down shaft	10
1905 Feb. 18	Lytle	Minersville	Fall of roof	5
1905 Mar. 9	Clear Spring	West Pittston	Fell down shaft	7
1905 Apr. 26	Conyngham	Wilkes-Barre	....do	10
1906 May 15	Shenandoah City	Shenandoah	Dynamite explosion	7

ACCIDENTS IN PENNSYLVANIA ANTHRACITE MINES IN WHICH 5 OR MORE MEN WERE KILLED—Continued.

Date.	Name of mine.	Location of mine.	Nature of accident.	Killed.
1906 Aug. 6	Susquehanna No. 7	Nanticoke	Mine explosion	6
1907 Mar. 2	Holden	Taylor	....do	7
1907 June 18	Johnson No. 1	Priceburg	....do	7
1908 May 12	Mount Lookout	Wyoming	....do	12
1908 May 13	Prospect	Wilkes-Barre	Fall of roof	5
1908 July 15	Williamstown	Williamstown	Powder explosion	6
1908 Aug. 28	Warrior Run	Wilkes-Barre	Mine cars	6
1909 Mar. 2	No. 14	Pittston	Mine explosion	8
1909 Nov. 9	Auchincloss	Nanticoke	Mine fire	9
1910 Jan. 11	Nottingham	Plymouth	Mine explosion	7
1910 Mar. 12	South Wilkes-Barre No. 5.	Wilkes-Barre	....do	7
1911 Apr. 7	Price-Pancoast	Throop	Mine fire	72
1911 May 27	Cameron	Shamokin	Mine explosion	5
1911 Sept. 12	Marvin	Scranton	Mine cars	5
1911 Oct. 3	Drifton No. 2	Freeland	Cave-in	5
1912 Jan. 9	Parrish	Plymouth	Mine explosion	6
1913 Aug. 2	East Brookside	Tower City	....do	19
1914 May 20	Maryd	Maryd	Overwinding of cage	6
1914 Sept. 16	Lehigh No. 4	Lansford	Mine explosion	7
1914 Dec. 9	Tripp	Scranton	Collapse of bottom of cage.	13
1915 Feb. 17	Prospect	Wilkes-Barre	Mine explosion	13

Since 1903, the Pennsylvania anthracite mines have been operated on a 9-hour working day, and, for comparison with other States in which the mines are operated 8 or 10 hours, Table 40 has been compiled. The table shows that the number of hours worked per year per man in the anthracite field is 1,985, as compared with 2,034 for the bituminous field. The fatality rate in the anthracite field based on the actual number of employees is 3.73, during the 10-year period 1903 to 1913, except 1909, whereas based on the number of 2,000-hour workers it is 3.76. The difference in this instance is slight, but for Ohio, where the hours worked per year are 1,495, the fatality rate

NUMBER OF HOURS WORKED IN AND ABOUT THE PENNSYLVANIA ANTHRACITE MINES AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day.[a] (all employees.)	Total hours per year.	Number of 2,000 hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	206	1,354,347	278,995,482	139,498	518	3.71
1904	200	1,402,749	280,549,800	140,275	595	4.24
1905	215	1,488,654	320,060,610	160,031	644	4.02
1906	195	1,461,195	284,933,025	142,467	557	3.91
1907	220	1,505,106	331,123,320	165,562	708	4.28
1908	200	1,567,566	313,513,200	156,757	678	4.33
1909[b]						
1910	229	1,525,473	349,333,317	174,667	601	3.44
1911	246	1,565,460	385,103,160	192,551	699	3.63
1912	231	1,566,270	361,808,370	180,904	601	3.32
1913	257	1,581,705	406,498,185	203,249	618	3.04

[a] Calculated on the 9-hour basis. [b] Census year.

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE PENNSYLVANIA ANTHRACITE MINES.[a]

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899				1907			
1900	[b] 100,000	[b] 3,500,000	[b] 35	1908			
1901				1909	771	8,016	10
1902	[b] 145,000	[b] 14,210,000	[b] 98	1910	2,853	15,739	6
1903				1911	5,900	36,958	6
1904	2,228	34,103	15	1912	151,958	6,913,475	45
1905	4,998	33,986	7	1913	64,086	481,678	8
1906	161,039	5,958,443	37	1914	26,115	179,743	7

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Approximate.

based on the actual number of men employed is 2.94, and on the number of 2,000-hour workers is 3.94. The fatality rate in Ohio on this basis more nearly equals the rate in the anthracite field than when based on the actual number of employees. From these tables, comparisons with other States may be readily made. The tables of statistics for the anthracite mines of Pennsylvania follow:

TABLE 124.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN PENNSYLVANIA (ANTHRACITE), BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.[a]

[Figures for total production and all items below horizontal lines selected from Mineral Resources, U. S. Geol. Survey. Figures in column 4 and all items above horizontal lines in columns 3 and 8 from State mine inspectors' reports. Figures in columns 5, 6, and 7, and averages in columns 9 and 10 prior to 1901, calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial arm or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1807–1869	232,765,704			*188*																	
1870	15,664,275		35,600	211	5.93	13.47	74,238		440												
1871	19,342,057		37,488	210	5.60	10.86	92,105		516												
1872	24,233,166		44,745	223	4.98	9.20	108,669		542												
1873	26,152,837		48,199	263	5.46	10.06	99,440		543												
1874	24,818,790		53,402	231	4.33	9.31	107,441		465												
1875	22,485,766		69,966	236	3.37	10.50	95,279		321												
1876	22,793,245		70,474	227	3.22	9.96	100,411		323												
1877	25,660,316		66,842	194	2.90	7.56	132,270		384												
1878	21,689,682		63,964	187	2.92	8.62	115,968		339												
1879	30,207,793		68,847	262	3.81	8.67	115,297		439												
1880	28,649,812		73,373	202	2.75	7.05	141,831		390												
1881	31,920,018		76,031	273	3.59	8.55	116,923	221	420	1.90											
1882	35,121,256		82,200	291	3.54	8.29	120,692	218	427	1.96											
1883	38,456,845		91,421	323	3.53	8.40	119,061	232	421	1.81											
1884	37,156,847		101,073	332	3.28	8.94	111,918	192	368	1.92											
1885	38,335,974	$2.00	100,324	359	3.58	9.36	106,785	204	382	1.87											
1886	39,035,446	1.95	103,044	278	2.70	7.12	140,415	196	379	1.93											
1887	42,088,197	2.01	106,517	314	2.95	7.46	134,039	208	395	1.90											
1888	46,619,564	1.91	122,218	364	2.98	7.81	128,076	218	381	1.75											
1889	45,546,970	1.44	123,676	385	3.11	8.45	118,304	194	368	1.90											
1890	46,468,641	1.43	126,000	378	3.00	8.13	122,933	200	369	1.85											
1891	50,665,431	1.46	126,350	428	3.39	8.45	118,377	203	401	1.98											
1892	52,472,504	1.57	129,050	418	3.24	7.97	125,532	198	407	2.06											
1893	53,987,543	1.59	132,944	455	3.42	8.43	118,610	197	406	2.06											
1894	51,921,121	1.85	131,603	445	3.38	8.57	116,677	190	395	2.08											
1895	57,999,337	1.41	142,917	421	2.95	7.26	137,766	196	406	2.07											

1896	54,346,081	1.50	148,991	501	3.36	9.22	108,475	174	365	2.10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1897	52,611,680	1.51	149,884	423	2.82	8.04	124,377	150	351	2.84	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1898	53,382,644	1.41	145,504	411	2.82	7.70	129,885	152	367	2.41	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1899	60,418,005	1.46	139,608	461	3.30	7.63	131,059	173	433	2.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1900	57,367,915	1.49	144,206	411	2.85	7.16	139,581	166	398	2.40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1901	67,471,667	1.67	145,309	513	3.53	7.60	131,524	196	464	2.37	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1902	41,373,595	1.84	148,141	300	2.03	7.25	137,912	116	279	2.41	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1903	74,607,068	2.04	150,483	518	3.44	6.94	144,029	206	496	2.41	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1904	73,156,709	1.90	155,861	595	3.82	8.13	122,952	200	469	2.35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1905	77,659,850	1.83	165,406	644	3.89	8.29	120,590	215	470	2.19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1906	71,282,411	1.85	162,355	557	3.43	7.81	127,976	195	439	2.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1907	85,604,312	1.91	167,234	708	4.23	8.27	120,910	220	512	2.33	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1908	83,268,754	1.90	174,174	678	3.89	8.14	122,815	200	478	2.39	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1909	81,070,359	1.84	166,801	567	3.40	6.99	142,981	(b)	486	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1910	84,485,236	1.90	169,497	601	3.55	7.11	140,574	229	498	2.17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	308
1911	90,464,067	1.94	173,940	699	4.02	7.73	129,419	246	520	2.11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	292
1912	84,361,598	2.11	174,030	601	3.45	7.12	140,369	231	485	2.10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	275
1913	91,524,922	2.06	175,745	618	3.52	6.75	148,099	257	521	2.03	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	278
Total	2,446,696,010	.....	.....	17,902	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (1870–1913)	50,316,598	.....	117,851	402.64	3.42	8.00	194,968	200	427	2.14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	90,821,507	2.07	179,679	595	3.31	6.55	152,641	245	505	2.06	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	271

a Figures in italics represent incomplete fatality records.

b Not reported.

TABLE 125.—NUMBER OF MEN KILLED IN AND ABOUT THE ANTHRACITE MINES IN PENNSYLVANIA, WITH FATALITIES CLASSIFIED ACCORDING TO CAUSE, DURING THE CALENDAR YEARS 1870 TO 1914, INCLUSIVE.

| Year. | Underground. | | |

| | | |

PENNSYLVANIA (BITUMINOUS).

AREA AND DISTRIBUTION OF COAL FIELDS.

The bituminous coal fields of Pennsylvania are in the western and southwestern part of the State, and comprise the northern end of the great Appalachian series of coal measures. The fields include about 14,200 square miles, covering 12 counties and parts of 21 other counties. The structure conforms to the system of Appalachian folding in long northeast-southwest waves, locally modified more or less by minor cross folds. In the northwestern part of the area the strata gently undulate, with extremely slight dips, generally of but a few feet to the mile, but in passing eastward these undulations increase to well-marked folds along the eastern margin of the main body of the coal field.

CHARACTER OF COAL BEDS.

The bituminous coal fields of Pennsylvania are described by Parker[a] as follows:

The coal-bearing rocks all belong to the Pennsylvania series and have a total thickness in the southwest corner of the State of about 2,600 feet. The great bulk of the coal mined comes from the Allegheny and the Monongahela formations, formerly known as the "Lower" and the "Upper Productive Coal Measures." Below the Allegheny formation is the Pottsville, containing, in the western part of the State, the Sharon and the Mercer coals, which have been worked only in restricted areas. The Allegheny formation, with a thickness of 250 to 350 feet, contains at least seven coal horizons, all of which yield workable coal locally. They are called, beginning at the bottom, the Brookville, Clarion, Lower Kittanning, Middle Kittanning, Upper Kittanning, Lower Freeport, and Upper Freeport coals. It is now definitely recognized that the coals of these horizons do not occur in continuous beds, and in many cases not in exactly the same horizons; yet it is clear that the corresponding geologic horizons mark times of conditions generally favorable for coal formation, and that no coal of wide extent is found at other levels. As a rule, the coal beds are not characterized by details of section, roof, or floor by which they can be clearly recognized, except over limited parts of the field. No one of them is continuously workable, but the Lower Kittanning and the Upper Freeport coals are widely workable, and the Lower Freeport has a splendid development over several counties in the northeast part of the field. The Brookville or A coal is of workable thickness in spots over a large part of the marginal belt of the coal measures, especially in Jefferson, Clearfield, Center, Cambria, and Somerset counties. The Clarion or A′ coal reaches workable thickness in about the same belt, though the two are seldom of workable thickness in the same section. Both of these coals are apt to be impure when thick. The lower Kittanning or B coal is the most persistent, uniform, and reliable of the Allegheny coals, although it is thinner than the Freeport coals, seldom exceeding a thickness of 4 feet. It is exposed in workable thickness and purity in 11 of the counties. The Middle and the Upper Kittanning horizons, C and C′, contain but little workable coal, though the Upper Kittanning shows cannel coal at a number of points and stands fourth in productivity. The Lower Freeport coal, D, is finely developed in Clearfield, Jefferson, Indiana, and Cambria counties—in the well-known Moshannon (Clearfield), Reynoldsville-Punxsutawney, and Barnesboro-Patton basins. Over most of the rest of the territory this seam is either worthless or of too low grade for competition in the present market. The Upper Freeport or E coal is a variable and complex bed, extending in gross workable thickness over most of its area, although over a considerable

[a] Parker, E. W., Coal: Mineral Resources of the United States for 1910, U. S. Geol. Survey, pt. 2 p. 195.

part of this territory it is too much broken up and too impure for profitable mining. It appears to be entirely absent in some localities.

As a whole, the Allegheny formation yields about 40 per cent of the total output of bituminous coal in the State.

For about 600 feet above the Upper Freeport bed occurs the Conemaugh formation or "Lower Barren Measures." It contains six or more coals, which, however, are workable only in very restricted areas, their best development being found in the Berlin Basin in Somerset County.

Just above the Conemaugh formation lies the Pittsburgh coal, the most uniform in quality and thickness, and for a given area the most valuable coal bed in the bituminous field of Pennsylvania. Although not of as high a grade as the best Allegheny coals to the east, and although varying greatly in quality from east to west, on the whole the Piftsburgh coal, on account of its thickness, its regularity, its high grade, its adaptability for the production of coke and illuminating gas, has long been the most famous bituminous coal bed in America. It is confined to the southwestern part of the State. The bed gives 9 feet of available coal over large areas, and seldom runs under 4 feet. Above the Pittsburgh coal occur the Redstone, Sewickley, Uniontown, and Waynesburg coals, which are of good workable thickness locally, but in the presence of the great Pittsburgh coal are but little mined.

METHODS OF MINING.

The earliest records of the United States Geological Survey show that bituminous coal has been mined in Pennsylvania since 1840. Most of the bituminous coal mines of Pennsylvania are opened by drift from the outcrop, or by a gentle slope down the dip of the bed. There are but few relatively deep mines as compared with the deep coal mines of Europe, the anthracite fields of Pennsylvania, or the metal mines. In the earlier years of the industry many of the mines were opened by single entry, but in recent years the larger operations and newer mines are opened by double or triple entry. The room-and-pillar system is used throughout the bituminous fields of Pennsylvania.

In 1896 about 12 per cent of the coal was reported as being mined by machines. The amount of coal produced by machines has steadily increased until in 1914 it was 53.8 per cent. Shooting off the solid is not extensively practiced, the total amount of coal thus produced being less than 3 per cent. About 35 per cent of the coal is reported as being mined by hand. In 1914, there were 6,326 machines in operation.

Table 54 shows the increase in mechanical haulage in the bituminous mines from 1899 to the close of 1913. In 1899 there were 122 electric locomotives in operation and in 1913, 1,933. The number of compressed-air locomotives has also increased from 13 in 1899 to 168 in 1913. The number of mules and horses used in underground haulage has practically doubled since 1898. The amount of black powder (Table 50) used in the bituminous coal mines has a little more than doubled since 1899, whereas the use of dynamite increased gradually from 1899 to 1907. Since 1907 the amount of dynamite used has decreased rapidly, and has largely been replaced by the use of permissible explosives.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

The first law providing for the inspection of bituminous mines in Pennsylvania, approved April 18, 1877, applied to all mines employing more than 10 men, except mines which did not generate fire damp, black damp, or other dangerous or noxious gases. A board of examiners was provided for the purpose of examining applicants for appointment as mine inspector. From a list of eligibles thus established the governor was authorized to appoint three inspectors, one for each of three districts into which the bituminous coal fields were to be divided by the examining board. Each inspector was required to examine all mines in his district as often as possible, to make a record of such examinations, showing the number of employees, number of deaths and injuries in and about the mines, and to file a record thereof each month in the office of the secretary of internal affairs, to be included by the secretary in the annual report of his department. Operators were required to notify the district inspector of all fatal and serious accidents, and on receiving such notice the inspector was required to visit the mine and investigate the cause of the accident.

An act approved May 25, 1878, repealed the provision in the law of April 18, 1877, which exempted from the inspection law those mines which did not generate fire damp, black damp, or other noxious or dangerous gases. The law of June 3, 1881, increased the number of inspection districts to four, and the number was further increased to six by an act approved June 13, 1883. The latter law also required the inspectors to make annual reports to the secretary of internal affairs.

On June 30, 1885, the examining board was authorized to divide the bituminous coal fields into eight districts, the governor to appoint a mine inspector for each district. An act approved May 15, 1893, authorized the examining board to further divide the bituminous fields into districts of not less than 60 mines nor more than 80 mines, and the governor was authorized to appoint an inspector for each district established by the board.

The number of inspectors was increased in 1894 to 10, in 1901 to 12, in 1903 to 15, in 1905 to 16, in 1906 to 18, in 1907 to 20, in 1909 to 21, in 1911 to 25, in 1912 to 26, in 1913 to 28, and in 1915 to 30.

Mine foremen were required to make monthly reports to the district inspector showing all accidents resulting in personal injury to mine employees. On June 9, 1911, an act was approved by which the State was divided into 25 bituminous districts and the chief of the department of mines was authorized to increase the number of districts with the approval of the governor. The district inspectors were directed to render both monthly and annual reports to the chief of the department of mines, and to enumerate all accidents in and about the mines.

Under the inspection laws it is the practice of the operators to report to the district inspectors all injuries causing disability for 6 days or more. The district inspectors, in their reports to the department of mines, omit accidents of a less serious nature, so that only the more serious injuries are published in the annual report of the department of mines. The department has not officially defined a serious injury, and it is left to the discretion of the district inspectors as to which of the accidents reported to them by mine operators may be eliminated from their reports to the department.

ACCIDENTS.

Tables 126 and 127 show the production of coal, number of men employed, and the number of fatalities in and about the bituminous coal mines of Pennsylvania. The record of the number of men employed and the fatalities is complete from the beginning of inspection service in 1877 to the end of 1913. The fatalities, as shown in the accompanying tables, have been compiled from the annual volumes of the State mine inspectors' reports. In a few instances slight changes have been introduced, owing to the fact that some of the earlier inspectors' reports included accidents at coke ovens, and others included deaths due to natural causes. In all cases where sufficient information was given, all fatalities that occurred which were foreign to the mining operations have been excluded from the tables.

During the 37-year period 1877 to 1913, inclusive, there were 9,473 fatalities attributed directly to the coal-mining industry. This represents a fatality rate of 2.87 per 1,000 men employed. The amount of coal mined per fatality, during the entire period, was 271,832 tons, or there were 3.68 fatalities per million tons mined. Since 1879, there have been 37 mine disasters in each of which 5 or more men were killed at one time, the total fatalities thus represented being 1,268, or about 13 per cent of the entire number since 1877. Of the total number of fatalities, 56.93 per cent was due to falls of roof; 15.33 per cent to mine cars and locomotives; and 13.82 per cent to gas and dust explosions. The fatality rate due to explosives is exceedingly low, being only 1.95 per cent of the total, as compared with 24.81 per cent in Kansas, 19.44 per cent in Indiana, 13.47 per cent in Illinois, and 3.27 per cent in West Virginia.

FATALITIES IN PENNSYLVANIA BITUMINOUS COAL MINES, BY PRINCIPAL CAUSES DURING THE YEARS 1877 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	5,393	56.93	1.64
Mine cars and locomotives	1,452	15.33	.44
Gas and dust explosions	1,309	13.82	.40
Explosives	185	1.95	.05
Miscellaneous	512	5.40	.16
Shaft	217	2.29	.06
Surface	405	4.28	.12
Total, 36 years	9,473	100.00	2.87

ACCIDENTS IN PENNSYLVANIA BITUMINOUS MINES IN WHICH 5 OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Nature of accident.	Number killed.
1879 Nov. 2	Mill Creek	Mill Creek	Mine explosion	5
1884 Feb. 20	West Leisenring	West Leisenring	do	19
1884 Oct. 27	Youngstown	Uniontown	do	14
1887 Oct. 1	Bast	Big Mine Run	Suffocated by inrush of mine gas.	5
1888 Nov. 3	Kettle Creek	Clinton County	Powder and coal-dust explosion.	17
1890 June 16	Hill Farm	Dunbar	Mine fire	31
1891 Jan. 27	Mammouth	Mount Pleasant	Mine explosion	109
1896 Mar. 23	Berwind	Dubois	do	13
1898 Sept. 23	Umpire	Brownsville	do	8
1899 July 24	Grindstone	Grindstone	do	5
1899 Dec. 23	Sumner	Sumner	do	19
1901 June 10	Port Royal No. 2	Port Royal	do	19
1902 Mar. 6	Catsburg	Monongahela	do	5
1902 July 10	Rolling Mill	Johnstown	do	112
1903 Nov. 21	Ferguson	Connellsville	do	17
1904 Jan. 25	Harwick	Cheswick	do	179
1905 Apr. 27	Eleanora	Dubois	do	13
1905 July 6	Fuller	Searight	do	6
1905 Oct. 13	Clyde	Fredericktown	Mine fire	6
1905 Oct. 29	Hazel Kirk No. 2	Monongahela	Mine explosion	5
1905 Nov. 15	Braznell	Bentleyville	do	7
1906 Oct. 24	Rolling Mill	Johnstown	do	7
1907 Aug. 17	Sonman	Sonman	Fell down shaft	5
1907 Dec. 1	Naomi	Fayette City	Mine explosion	34
1907 Dec. 19	Darr	Jacobs Creek	do	239
1908 Nov. 28	Rachel and Agnes	Marianna	do	154
1909 Jan. 25	Orenda No. 2	Boswell	do	5
1909 Apr. 9	Eureka No. 37	Windber	Dynamite and mine explosion.	7
1909 June 23	Lackawanna No. 4	Wehrum	Mine explosion	21
1909 Oct. 31	Franklin No. 2	Johnstown	do	13
1910 Feb. 5	Ernest No. 2	Ernest	do	12
1911 Mar. 22	Hazel	East Canonsburg	Fall of roof	9
1911 July 13	Sykesville	Sykesville	Mine explosion	21
1911 Nov. 9	Adrian	Punxsutawney	do	8
1912 July 24	Superba and Lemont	Evans Station	Cloudburst flooded mine.	[a] 18
1913 Apr. 23	Cincinnati	Finleyville	Mine explosion	96
1915 May 24	Smokeless Valley No. 1	Johnstown	do	9
1915 July 30	Patterson No. 2	Elizabeth	Mine cars	9
1915 Aug. 31	Orenda	Boswell	Mine explosion	19

[a] Not included in State inspector's tabular statement of mine fatalities.

Table 127 showing the fatalities by causes has been amplified from the bureau's regular form by subdivisions under "Falls of roof and coal," "Gas and dust explosions," "Miscellaneous underground," and "Miscellaneous surface." This is in conformity with the State inspector's latest reports, and in no way does it conflict with the bureau's classification in comparing fatalities by causes with those of other States. The main headings have been maintained as indicated in the table by numerals; the subheadings are indicated by letters. This classification gives operators, inspectors, and others an opportunity to study the mine accidents more in detail.

Since 1903 practically one-half of the men in the bituminous coal mines of the State have been on an 8-hour basis, as shown in the accompanying table, the remainder being 9 and 10 hour men. In order to make a true comparison of Pennsylvania with other States Tables 40 and 41 have been compiled showing the fatality rate based on the actual number of men employed and also on the number of calculated 2,000-hour workers. The number of hours worked per year per man in the Pennsylvania bituminous fields is 2,034, so that

there is but slight variation in the fatality rate based on the actual number of employees during the 10-year period 1903 to 1913 (except 1909) which is 3.39 per 1,000, and that based on the number of 2,000-hour workers, which is 3.34. The number of hours worked in Virginia is 2,447, in West Virginia 2,132, and in Ohio 1,495. With such varying periods of exposure to the hazards of the mining industry, it is essential that the time factor be taken into consideration.

NUMBER OF HOURS TO THE WORKING DAY, BY YEARS, IN AND ABOUT THE PENNSYLVANIA BITUMINOUS MINES.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, or 10 hours per day.	Total number of men employed.
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	481	58,761	220	28,221	170	32,192	10,091	129,265
1904	637	77,960	223	24,972	187	30,286	1,882	135,100
1905	669	60,297	226	26,090	179	31,314	25,928	143,629
1906	744	92,082	233	25,695	190	30,895	3,427	152,099
1907	809	96,667	260	24,883	198	35,355	6,390	163,295
1908	764	99,406	241	24,828	197	38,125	3,602	165,961
1909[b]								159,321
1910	834	101,208	272	30,270	225	37,769	6,156	175,403
1911	842	99,522	273	28,204	213	37,586	5,796	171,108
1912	774	91,928	316	32,935	214	35,322	4,959	165,144
1913	849	100,568	312	32,064	242	38,671	893	172,196

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE PENNSYLVANIA BITUMINOUS MINES, AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day (all employees).	Total hours per year.	Number of 2,000-hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	235	1,136,816	267,151,760	133,576	395	2.96
1904	196	1,168,226	228,972,296	114,486	533	4.66
1905	231	1,263,678	291,909,618	145,955	475	3.25
1906	231	1,307,704	302,079,624	151,040	476	3.15
1907	255	1,408,343	359,127,465	179,564	799	4.45
1908	201	1,432,368	287,905,968	143,953	571	3.97
1909						
1910	238	1,515,188	360,614,744	180,307	521	2.89
1911	233	1,478,036	344,382,388	172,191	515	2.99
1912	252	1,429,690	360,281,880	180,141	446	2.48
1913	267	1,487,867	397,260,489	198,630	609	3.07

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE PENNSYLVANIA BITUMINOUS MINES.[a]

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899	15,131	636,160	42	1907	6,447	59,834	9
1900	7,574	223,093	29	1908	18,780	375,569	20
1901	2,541	125,116	49	1909	5,824	260,381	45
1902	12,580	264,862	21	1910	60,098	2,700,746	45
1903	12,805	321,925	25	1911	5,601	148,124	26
1904	9,336	576,353	62	1912	22,538	538,248	24
1905	5,686	186,250	33	1913	17,244	274,296	16
1906	59,593	3,941,835	66	1914	36,613	1,052,005	29

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 126.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN PENNSYLVANIA (BITUMINOUS), BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.[a]

[Figures for total production and all items below horizontal lines in various columns selected from Mineral Resources, U. S. Geological Survey. Figures in column 4 and items above horizontal lines in column 3 compiled from State mine inspectors' reports. Figures in columns 5, 6, and 7 and averages in columns 9 and 10 prior to 1900 calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial axe or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1840–1876	156,877,404	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1877	14,000,000	.....	16,627	[b] 14	[b] 0.57	[b] 4.00	[b] 250,000	.....	842	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1878	15,120,000	.....	25,787	48	1.86	3.17	315,000	.....	586	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1879	16,240,000	.....	27,286	55	2.02	3.39	295,273	.....	595	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1880	18,425,163	.....	33,391	49	1.47	2.66	376,024	.....	552	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1881	22,400,000	.....	35,530	57	1.60	2.54	392,982	.....	630	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1882	24,640,000	.....	42,393	92	2.17	3.73	267,826	.....	581	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1883	26,880,000	.....	35,091	54	1.54	2.01	497,778	.....	766	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1884	28,000,000	.....	39,904	119	2.98	4.25	235,294	.....	702	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1885	26,000,000	$0.95	44,145	68	1.54	2.62	382,353	(c)	589	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1886	27,094,501	.80	52,364	74	1.41	2.73	366,142	(c)	517	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1887	31,516,856	.90	57,868	84	1.45	2.67	375,201	222	545	2.45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1888	33,796,727	.95	61,565	90	1.46	2.66	375,519	(c)	549	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1889	36,174,089	.77	62,084	103	1.66	2.85	351,205	(c)	583	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1890	42,302,173	.84	61,333	145	2.36	3.43	291,739	232	690	2.97	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1891	42,788,490	.87	63,661	236	3.71	5.52	181,307	223	672	3.01	.....	.....	.....	.....	.....	.....	.....	.....	.....	72	.....
1892	46,694,576	.84	66,655	134	2.01	2.87	348,467	223	701	3.14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1893	44,070,724	.80	71,931	131	1.82	2.97	336,418	190	613	3.23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1894	39,912,463	.74	75,010	123	1.64	3.08	324,492	165	532	3.22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1895	50,217,228	.72	71,130	153	2.15	3.05	328,217	206	706	3.43	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1896	49,557,453	.71	72,625	178	2.45	3.59	278,413	206	682	3.31	.....	12.3	.....	.....	.....	.....	.....	.....	.....	454	.....
1897	54,417,974	.69	77,272	149	1.93	2.74	365,221	205	704	3.43	.....	16.4	.....	.....	.....	.....	.....	.....	.....	690	.....
1898	65,165,133	.67	79,611	199	2.50	3.05	327,463	229	819	3.58	.....	25.3	.....	.....	.....	.....	.....	.....	.....	1,085	.....
1899	74,150,175	.76	82,812	258	3.12	3.48	287,404	245	895	3.65	.....	29.7	.....	.....	944	399	.....	.....	.....	1,343	.....
1900	79,842,326	.97	92,692	264	2.85	3.31	302,433	242	861	3.56	.....	33.7	.....	.....	.....	.....	.....	.....	.....	1,786	.....
1901	82,305,946	.99	101,904	301	2.95	3.66	273,442	230	808	3.51	.....	36.0	.....	.....	.....	.....	.....	.....	.....	2,058	.....
1902	96,574,367	1.08	112,630	455	4.04	4.62	216,647	248	875	3.53	.....	35.6	.....	.....	.....	.....	.....	.....	.....	2,620	.....

1903	103,117,178	1.18	129,265	395	3.06	3.83	261,056	235	798	3.40	.....	36.0	.....	.....	2,267	1,039	4	.....	.....	3,310	.....
1904	97,938,287	.96	135,100	533	3.95	5.44	183,749	196	725	3.70	.....	35.9	.....	.....	2,455	1,175	15	.....	.....	3,645	.....
1905	118,413,637	.96	143,629	475	3.31	4.01	249,292	231	824	3.57	.....	41.7	.....	.....	3,020	1,232	2	.....	.....	4,254	.....
1906	129,293,206	1.00	152,099	476	3.13	3.68	271,624	231	850	3.68	.....	41.9	.....	.....	3,103	1,393	19	.....	.....	4,515	.....
1907	150,143,177	1.04	163,295	799	4.89	5.32	187,914	255	919	3.60	.....	40.5	.....	.....	3,372	1,547	21	.....	.....	4,940	.....
1908	117,179,527	1.01	165,961	571	3.44	4.87	205,218	201	706	3.51	.....	44.8	.....	.....	3,436	1,059	8	.....	.....	5,103	.....
1909	137,966,791	.94	159,321	500	3.14	3.62	275,934	(c)	866	(c)	.....	41.7	.....	.....	3,847	1,731	38	.....	.....	5,616	1,492
1910	150,521,526	1.02	175,403	521	2.97	3.46	288,909	238	858	3.61	.....	45.5	.....	.....	3,534	1,872	86	13	.....	5,505	1,476
1911	144,561,257	1.01	171,108	515	3.01	3.56	280,701	233	845	3.63	34.3	47.8	2.6	15.3	3,556	1,874	82	188	19	5,719	1,486
1912	161,865,488	1.05	165,144	446	2.70	2.76	362,927	252	980	3.89	33.7	50.8	3.0	12.5	3,660	2,023	52	439	2	6,176	1,477
1913	173,781,217	1.11	172,196	609	3.54	3.50	285,355	267	1,009	3.78	35.4	53.2	2.6	8.8	3,341	2,086	137	736	1	6,301	1,503
Total	2,731,945,059	.....	.....	9,473	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (1877–1913)	69,596,422	.....	89,076	256.63	2.87	3.68	271,832	229	781	3.41	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	147,983,294	1.07	184,201	402	2.18	2.72	368,118	214	803	3.75	37.2	53.8	2.0	7.0	3,140	1,927	96	1,156	7	6,326	1,482

a Figures in italics represent incomplete fatality records.

b Oct. to Dec. 31 only.

c Not reported.

TABLE 127.—NUMBER OF MEN KILLED IN AND ABOUT THE **BITUMINOUS** MINES IN **PENNSYLVANIA**, WITH FATALITIES CLASSIFIED ACCORDING TO CAUSE, DURING THE CALENDAR YEARS 1877 TO 1914, INCLUSIVE.

Year.	Killed underground.																																Killed in shaft.				Killed on surface.																Grand total.
	Falls of roof (coal, rock, etc.). 1						Falls of face or pillar coal. 2				Mine cars and locomotives. 3						Gas explosions and burning gas. 4					5	6	7	8	9	10	11	Other causes. 12							Total underground.	13	14	15	16	Total shaft.	17	18	19	20	21	Other causes. 22				Total surface.	
	a	b	c	d	e	Total.	a	b	c	Total.	a	b	c	d	e	Total.	a	b	c	d	Total.	Coal dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	a	b	c	d	e	f	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Mine cars and locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	a	b	c	d	Total.	
	At face.	*At pillar.*	*On entry.*	*In room.*	*On slope.*		*At face.*	*At pillar.*	*On entry.*		*On entry.*	*In room.*	*On slope or plane.*	*At foot of slope or shaft.*	*At dump chute.*		*In room.*	*On entry.*	*In old workings.*	*In heading, tunnel, or slope.*									*Machinery.*	*Rush of coal or gob.*	*Struck by coal or rock.*	*Falling timber.*	*Fall of person.*	*Miscellaneous.*													*Suffocation in chutes, bins, or culm.*	*Falls of persons.*	*Explosives.*	*Miscellaneous.*			
1877 [a]	8	..	..	..	..	8	3	..	..	3	2	..	..	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	13	1	..	..	1	6	..	..	..	..	..	..	..	..	..	14
1878	26	..	1	..	..	27	9	1	..	10	1	..	..	..	..	1	..	..	..	..	..	..	1	2	..	..	..	..	..	..	..	..	..	..	..	41	..	..	..	..	15	..	..	7	..	..	..	..	..	22	63
1879	26	..	1	..	..	27	15	..	..	15	6	..	..	..	..	6	4	..	..	..	4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	56	..	..	..	..	15	..	..	7	..	..	..	..	..	22	78
1880	23	..	..	2	..	25	13	..	..	13	5	..	..	..	..	5	1	..	..	..	1	..	..	..	..	1	..	..	..	..	..	..	..	..	..	47	..	..	..	..	1	..	..	..	..	1	..	..	..	2	49
1881	25	1	2	1	..	29	2	4	..	6	9	..	3	..	..	12	1	1	..	1	3	..	..	..	..	4	..	..	..	..	..	2	..	..	2	56	..	..	..	..	1	..	1	..	..	..	..	..	..	2	58
1882	25	3	4	9	..	41	18	2	..	20	7	1	..	..	..	8	7	1	..	..	8	..	2	..	..	..	..	..	..	..	1	..	..	..	1	82	2	..	2	..	4	6	..	1	..	1	..	..	..	8	94
1883	19	8	4	5	..	36	5	3	2	10	5	..	..	..	..	5	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	1	52	..	1	..	1	2	1	..	..	..	..	..	..	..	1	55
1884	40	4	3	..	..	47	22	..	..	22	9	..	..	1	..	10	21	14	..	1	36	..	1	..	..	..	..	..	..	..	..	..	..	3	3	116	..	..	..	1	1	..	..	..	..	..	..	..	..	..	117
1885	30	5	..	3	..	38	9	1	..	10	9	..	1	..	..	10	1	..	..	..	1	..	1	..	..	1	..	..	..	..	..	4	5	..	10	68	..	..	..	..	..	..	..	..	..	..	..	..	..	..	68
1886	31	6	1	..	..	38	9	1	..	10	13	..	1	1	..	15	6	..	..	..	6	..	2	..	..	..	..	..	..	..	..	..	..	..	..	71	1	..	..	..	1	2	..	..	..	..	..	2	..	2	74
1887	26	3	..	2	..	31	21	..	..	21	16	..	1	..	..	17	..	3	..	2	5	..	3	..	..	1	..	..	..	..	..	1	..	..	1	79	3	1	1	..	5	..	..	..	..	..	..	..	..	..	84
1888	31	5	1	2	..	39	13	1	..	14	7	..	1	1	..	9	1	17	..	..	18	3	1	..	1	..	..	..	..	..	..	2	2	..	5	87	..	..	1	..	1	1	..	..	..	..	1	1	..	2	90
1889	38	4	1	5	..	48	19	3	..	22	9	..	..	1	..	10	6	..	..	..	6	..	2	..	..	..	..	..	..	..	1	..	1	2	2	90	2	..	2	3	7	4	..	2	..	..	..	..	..	..	103
1890	45	7	2	5	..	62	18	1	..	19	13	..	2	..	1	16	..	..	..	..	..	..	5	..	..	1	..	..	31	..	..	1	2	3	3	137	2	..	1	..	3	2	..	..	..	..	1	..	2	3	145
1891	55	4	4	5	..	68	16	1	1	18	17	..	1	..	..	18	111	..	..	..	111	..	5	..	..	..	..	..	3	..	..	..	2	2	4	227	1	2	3	..	6	2	..	..	..	..	1	..	1	2	236
1892	59	9	4	4	..	76	12	6	..	18	30	..	1	..	..	31	1	..	..	..	1	..	2	..	..	..	..	..	..	..	..	..	..	..	..	128	1	..	1	..	2	1	..	1	..	2	..	..	2	4	134

| | | |

TENNESSEE.

AREA AND DISTRIBUTION OF COAL FIELDS.

The coal fields of Tennessee are from 50 to 70 miles wide and extend northeast and southwest across the State from Chattanooga on the south to Middlesboro, Ky., on the north. The coal-bearing areas comprise about 4,400 square miles, of which it is estimated about 47 per cent may contain coal of economic value.

The coal fields may for convenience be divided into a northern and a southern division. The northern area, which produces most of the coal mined, may be subdivided into the Jellico Basin, comprising parts of Campbell and Scott counties; the Wartburg Basin, including parts of Morgan, Anderson, and Scott counties; and the Middlesboro Basin, including Campbell and Claiborne counties. The southern division, which is known as the Chattanooga district, includes the Sewanee Basin, a part of the Cumberland plateau, the Walden Ridge Basin, and the Lookout Basin.

CHARACTER OF COAL BEDS.

The coal for the most part is bituminous throughout the State, but there is a limited area of cannel coal in the Jellico district. The beds, though reasonably uniform in thickness over limited areas, are relatively thin and the coal is variable in quality. The coal beds are nearly horizontal in most regions of extensive development except for local folds and rolls. The coals in the northern districts are a good grade of steam and domestic fuel, whereas in the southern districts the Sewanee coal is better adapted for coking purposes.

The Jellico coal in the Jellico district varies from 3 to 4 feet and the Blue Gem coal from 1½ to 2 feet. Many mines are operated in these two beds, but most of them are mines with a small output. The coal in the Middlesboro Basin varies from 4 to 5 feet in thickness and is extensively mined in Mingo Hollow and elsewhere. The coal in the Wartburg Basin is variable in thickness and quality, ranging from 3 to 5 feet in thickness.

The coal in the Chattanooga district is nearly horizontal except over local areas, as along Walden Ridge, where it is greatly disturbed. The Sewanee coal ranges from about 2½ to 4½ feet in thickness and is generally found badly crushed and contorted and sometimes intimately mixed with "rash," which in this crushed form is very difficult to separate from the coal.

MINING METHODS.

The earliest records for the production of coal in Tennessee are those of 1840, during which year 558 tons were mined. The production has gradually increased and in 1913 amounted to 6,903,784 tons. The mines are practically all opened by drifts, a few by slopes, and only two by shafts, and the coal is mined largely by the

room-and-pillar system. Few of the mines in the State are large producers and in many of them mule haulage alone is used. Roof conditions average fairly good when proper precautions are taken in timbering. About 57 per cent of the mines are ventilated by fans and about 30 per cent by furnaces. Most of the mines are wet and there is little chance for dust to gather, but some of them are very dry and considerable dust is produced in mining the coal. In a few of the dry mines adequate sprinkling cars are provided, but in two or three dry mines no attempt is made to sprinkle, and the mines are dangerously dusty.

There were 8 coal mining machines in use in 1897 and 252 in 1913. The amount of machine-mined coal for the latter year was 26.7 per cent of the total output, or 7,312 tons per machine. In 1912, 32.9 per cent of the coal mined was shot from the solid and in 1913, 37 per cent was mined by this method; 36.3 per cent was mined with hand picks.

As early as 1891 an agreement between mine operators and miners prohibited shooting coal off the solid, but this contract is too frequently broken in practice.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

The first mine-inspection law of Tennessee was passed April 7, 1881. It required that all accidents at mines should be reported to the inspector of the district in which the mine was located, and, if fatal, to the county coroner. The enforcement of the law was intrusted to the geologist of the bureau of agriculture, statistics, and mines, with power to employ such assistants as were necessary. The inspector was required to preserve in his office a record showing the cause of all accidents in the mines. An act approved March 29, 1887, consolidated the inspection service and placed it under the jurisdiction of one mine inspector, whose office was maintained at Chattanooga, and to whom all accidents were to be reported by the mine operators. The inspector rendered annual reports to the governor on January 1 of each year. On March 23, 1891, an act was approved by which the office of mine inspector was consolidated with the bureau of labor and mining statistics, under the supervision of the commissioner of the bureau of labor, statistics, and mines. The scope of the work of the new bureau was made to include the inspection of all mines, collieries, mills, and factories, and all accidents at such establishments resulting in loss of life or serious personal injury were to be reported to the commissioner of the bureau, the commissioner to render annual reports to the Governor.

An act of April 3, 1903, separated the mine inspection service from the bureau of labor and mining statistics, established the office of chief mine inspector, and authorized the governor to appoint one

chief inspector and two district mine inspectors, the chief to specify the counties which should compose the two districts. The act applied to both coal and metal mines, and the chief inspector was required to render annual reports to the governor, and to enumerate therein all accidents, both fatal and nonfatal.

ACCIDENTS.

Tables 128 and 129 show the production, number of men employed, and number killed in and about the coal mines of Tennessee as compiled from the reports of the United States Geological Survey and the State mine inspector's reports. Continuous records of fatalities have been kept since 1891 to the end of 1913. During this period there were 859 fatalities, representing a rate of 4.30 per 1,000 men employed. The amount of coal produced per fatality was 119,280 tons, or there were 8.38 fatalities per 1,000,000 tons mined. Of the total number of fatalities 42.03 per cent was due to falls of roof; 39.47 per cent to gas and dust explosions, whereas mine cars and locomotives caused 5.70 per cent, and explosives a like percentage.

FATALITIES IN TENNESSEE COAL MINES, BY PRINCIPAL CAUSES, DURING THE YEARS 1891 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	361	42.03	1.81
Mine cars and locomotives	49	5.70	.25
Gas and dust explosions	339	39.47	1.70
Explosives	49	5.70	.25
Miscellaneous	27	3.14	.13
Shaft	1	.12	.....
Surface	33	3.84	.16
Total, 23 years	859	100.00	4.30

COAL-MINE ACCIDENTS IN TENNESSEE IN WHICH 5 OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Nature of accident.	Number killed.
1895 Dec. 20	Nelson	Dayton	Mine explosion	25
1901 May 27	Richland	do	do	20
1902 Mar. 31	Nelson	do	do	16
1902 May 19	Fraterville	Coal Creek	do	184
1911 Dec. 9	Cross Mountain	Briceville	do	84

Since 1895 there have been five disasters in which 327 men were killed. A list of these disasters is given in an accompanying table.

Since 1903 slightly over one-half of the men have been employed at the mines on a 9-hour basis. During the 10-year period 1903 to 1913, excepting 1909, the men were employed 2,100 hours during the year. The fatality rate based on the actual number of employees as shown in Table 40 is 3.40, but when computed on the basis of equivalent 2,000-hour workers becomes 3.23. By comparing Tenn-

essee with Ohio on the basis of actual number of employees, it will be noted that the Tennessee rate is much higher, being 3.40 as compared with 2.94 for Ohio. The men in Ohio were employed 1,495 hours per annum, so that reducing the fatality rate to 2,000-hour workers the Tennessee rate is 3.23 as compared with 3.94 for Ohio. A similar comparison may be made with other States in tables 40 and 41.

NUMBER OF HOURS TO THE WORKING DAY, BY YEARS, IN AND ABOUT THE COAL MINES OF TENNESSEE.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, or 10 hours per day.	Total number of men employed.
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	1	9	54	5,614	23	3,415	923	9,961
1904	8	657	63	6,102	24	2,887	770	10,416
1905	8	876	62	5,693	33	4,463	896	11,928
1906	4	246	79	6,938	30	4,034	234	11,452
1907	13	1,561	75	6,968	27	3,379	144	12,052
1908	5	287	87	8,220	19	1,921	1,384	11,812
1909[b]								10,021
1910	5	451	86	7,566	32	3,395	518	11,930
1911	6	375	56	5,929	30	3,978	842	11,124
1912	5	317	77	5,720	29	3,980	292	10,309
1913	9	710	78	6,163	35	3,927	463	11,263

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN TENNESSEE AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day (all employees).	Total hours per year.	Number of 2,000-hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	227	93,055	21,123,485	10,562	26	2.46
1904	217	95,974	20,826,358	10,413	28	2.69
1905	221	110,939	24,517,519	12,259	29	2.37
1906	229	106,856	24,470,024	12,235	32	2.62
1907	232	110,286	25,586,352	12,793	30	2.35
1908	209	107,942	22,559,878	11,280	34	3.01
1909						
1910	225	110,314	24,820,650	12,410	38	3.06
1911	232	103,719	24,062,808	12,031	111	9.23
1912	234	96,444	22,567,896	11,284	18	1.60
1913	241	104,584	25,204,744	12,602	35	2.78

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN TENNESSEE.[a]

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899	1,595	37,085	23	1907	284	4,725	17
1900	1,559	67,308	43	1908	349	11,441	33
1901	1,705	82,730	49	1909	277	9,295	34
1902	1,904	136,347	72	1910			
1903	1,639	36,021	22	1911	163	1,630	10
1904	2,391	170,680	71	1912	670	20,011	30
1905	150	4,770	32	1913	857	42,966	50
1906	190	1,185	7	1914			

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 128.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN TENNESSEE, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.

[Figures for total production and all items below horizontal lines in various columns selected from Mineral Resources, U. S. Geol. Survey. Figures in column 4 and all items above horizontal lines in columns 2 and 3 compiled from State mine inspectors' reports. Figures in columns 5, 6, and 7, and averages in columns 9 and 10 prior to 1900, calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial axe or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1840–1879	5,829,376																				
1880	495,131		1,210						409												
1881	840,000		1,500						560												
1882	850,000		2,075						410												
1883	1,000,000		2,285						438												
1884	1,200,000		3,500						343												
1885	1,440,957	$1.10	3,783						381												
1886	1,714,290	1.15	4,140						414												
1887	1,900,000	1.30	4,260						446												
1888	1,967,297	1.10	4,684						420												
1889	1,925,689	1.21	4,031					(a)	478												
1890	2,169,585	1.10	5,082					263	427	1.62											
1891	2,413,678	1.11	5,097	22	4.32	9.11	109,713	230	474	2.06											
1892	2,092,064	1.13	4,926	13	2.64	6.21	160,928	240	425	1.77											
1893	1,902,258	1.08	4,976	13	2.61	6.83	146,328	232	382	1.65											
1894	2,180,879	.97	5,542	14	2.53	6.42	155,777	210	394	1.88											
1895	2,535,644	.93	5,120	37	7.23	14.59	68,531	224	495	2.21											
1896	2,663,106	.86	6,531	22	3.37	8.26	121,050	211	408	1.93											
1897	2,888,849	.81	6,337	10	1.58	3.46	288,885	221	456	2.06		1.6								8	
1898	3,022,896	.77	6,643	19	2.86	6.29	159,100	234	455	1.94		5.0								19	
1899	3,330,659	.88	6,949	20	2.88	6.00	166,533	252	479	1.90		6.0			16	6				22	100
1900	3,509,562	1.14	7,646	10	1.31	2.85	350,956	242	459	1.90		4.8								18	114
1901	3,633,290	1.12	9,046	43	4.75	11.83	84,495	228	402	1.76		6.1								21	
1902	4,382,968	1.23	8,750	226	25.83	51.56	19,394	230	501	2.18		6.9								38	
1903	4,798,004	1.25	9,961	26	2.61	5.42	184,539	227	482	2.12		6.4			45	6				51	
1904	4,782,211	1.18	10,416	28	2.69	5.86	170,793	217	459	2.12		9.2			71	14				85	

1905	5,766,690	1.14	11,923	29	2.43	5.03	198,551	221	483	2.19	.....	8.3	.....	.....	77	12	.....	.....	.....	89	.....
1906	6,250,275	1.22	11,453	32	2.79	5.11	195,602	229	547	2.39	.....	11.9	.....	.....	112	14	2	.....	.....	128	.....
1907	6,810,248	1.25	12,052	30	2.49	4.41	227,008	232	585	2.44	.....	12.9	.....	.....	120	14	8	.....	.....	137	.....
1908	6,199,171	1.15	11,812	34	2.88	5.48	182,329	209	525	2.61	.....	12.7	.....	.....	96	18	8	.....	.....	122	.....
1909	6,358,645	1.09	10,031	29	2.89	4.56	219,264	(a)	634	(a)	.....	16.4	.....	.....	119	54	24	.....	.....	197	132
1910	7,121,380	1.11	11,980	38	3.19	5.34	187,405	225	697	2.66	.....	17.2	.....	.....	131	22	13	12	.....	178	129
1911	6,433,156	1.12	11,124	111	9.98	17.25	57,856	232	578	2.49	35.2	14.2	37.7	12.9	121	15	9	31	3	179	130
1912	6,473,228	1.14	10,309	18	1.75	2.78	359,624	234	628	2.68	41.8	18.6	32.9	6.7	154	17	15	39	2	227	119
1913	6,903,784	1.14	11,263	85	3.11	5.07	197,251	241	613	2.54	35.7	26.7	37.0	.6	176	21	4	50	1	252	134
Total	123,703,905	.....	.....	859	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (1891–1913)	4,464,864	.....	8,669	27.85	4.80	8.38	119,280	225	513	2.35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	5,943,258	1.14	10,116	26	2.67	4.37	226,587	220	588	2.67	39.1	23.2	37.6	.1	126	9	5	54	.....	194	126

a Not reported.

TABLE 129.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN TENNESSEE, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE DURING THE CALENDAR YEARS 1891 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1891	12	1	.....	.....	.....	5	.....	.....	.....	.....	.....	1	19	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	3	22
1892	10	1	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13
1893	3	3	2	.....	.....	.....	.....	.....	.....	.....	.....	3	11	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	2	13
1894	12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	.....	.....	.....	.....	.....	.....	.....	1	.....	1	.....	2	14
1895	5	2	.....	.....	28	2	.....	.....	.....	.....	.....	.....	37	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	37
1896	16	2	1	.....	.....	2	.....	.....	.....	.....	.....	.....	21	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	1	22
1897	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10
1898	13	1	1	1	.....	1	.....	.....	.....	.....	.....	.....	17	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	2	19
1899	13	.....	3	.....	.....	2	.....	.....	.....	.....	.....	.....	18	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	2	20
1900	8	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10
1901	16	1	3	.....	20	1	.....	.....	.....	1	.....	1	43	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	43
1902	17	1	5	.....	200	3	.....	.....	.....	.....	.....	.....	226	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	226
1903	15	.....	2	.....	.....	2	.....	1	.....	.....	.....	.....	20	.....	.....	.....	.....	.....	6	.....	.....	.....	.....	.....	6	26
1904	19	.....	4	.....	3	2	.....	.....	.....	.....	.....	.....	28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	28
1905	18	.....	2	.....	.....	7	.....	1	.....	.....	.....	.....	28	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	29
1906	20	.....	3	.....	.....	3	.....	.....	.....	.....	.....	2	28	1	.....	.....	.....	1	2	.....	.....	.....	.....	1	3	31
1907	19	1	3	3	.....	1	.....	2	.....	.....	.....	.....	29	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	29
1908	26	1	.....	.....	.....	1	.....	4	1	.....	.....	.....	33	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	34
1909	18	.....	4	.....	.....	3	.....	2	.....	.....	.....	.....	27	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	2	29
1910	22	.....	3	.....	.....	10	.....	2	.....	.....	.....	.....	37	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	38
1911	14	.....	5	.....	84	1	.....	4	.....	.....	.....	.....	108	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	3	111
1912	13	1	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	2	18
1913	25	1	6	.....	.....	.....	.....	1	.....	.....	1	.....	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	25
1914	19	2	1	1	.....	1	.....	.....	.....	.....	.....	.....	24	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	26

TEXAS.

AREA AND DISTRIBUTION OF COAL FIELDS.

The coal-bearing rocks that carry bituminous coal comprise an area in northern Texas a little more than 200 miles long and 45 miles wide, but coal beds are limited to an area of about 8,200 square miles in Wise, Palo Pinto, Erath, and McCulloch counties. The structure of this field is a gentle monocline, the beds dipping northwest about 100 feet to the mile.

In the southern part of the State, near Eagle Pass, Maverick County, is a Cretaceous coal bed which is mined to some extent.

The Tertiary lignite beds extend entirely across the State from Mexico to Arkansas; the known workable areas cover about 2,000 square miles, and there are about 53,000 square miles that may contain workable beds. Of the total amount of coal mined, about one-half is lignite.

CHARACTER OF COAL BEDS.

In the bituminous field there are three workable beds, but the ones most largely mined are No. 1, which is the lowest, and No. 7, which is the highest. These coals are of Carboniferous age. No. 1 is continuous for at least 80 miles, and in Wise County is 14 to 26 inches thick; in Park County, 18 to 26 inches thick; in Palo Pinto County, 26 inches thick; and in Erath County, 28 inches thick.

With few exceptions the coal bed has a strong shale roof and shale floor. The No. 7 bed has the same structural features as No. 1 and is continuous for about 250 miles. It is 12 to 42 inches thick. Near Cisco the bed is 33 inches thick.

In the lignite field the beds that are worked are thick, generally ranging from 6 to 8 feet.

MINING METHODS.

The earliest coal-production report for Texas was in 1884, when 125,000 tons of coal was mined. The production for 1913 was 2,429,144 tons. Of the 48 mines in operation in 1913, 8 were opened by slopes, and 43 were opened by shafts varying from 45 to 418 feet in in depth. About one-half were opened by single entry and one-half by double entry. One-third of the mines are operated by the long-wall method, and two-thirds by the room-and-pillar method. Steam hoists are used at practically all of the mines. Electric and mule haulage are used underground, while 3 mines were using gasoline motors.

The majority of the mines are ventilated by fans and only two by furnaces. In 1897, there were 5 mining machines, and in 1913, 24 machines. In 1913, 61.5 per cent of the coal was mined by hand and 4.2 per cent by machines, and 25 per cent was shot off the solid.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

The law enacted by the Texas Legislature April 30, 1907, authorized the governor to appoint a State mine inspector for all coal mines, upon the recommendation of an examining board, also provided for by the act. The first inspector was appointed September 30, 1909, and was directed to see that the provisions of the mining law were properly enforced. The law, however, did not require mine operators to report accidents to the State inspector.

ACCIDENTS.

Tables 130 and 131 show the production of coal and the number of men employed in the mines of Texas since 1889. Complete accident records, however, were not kept prior to 1909. During the 5-year period 1909–1913, there were 25 fatalities reported in and about the coal mines of Texas, representing a rate of 1.06 per 1,000 men employed. The amount of coal mined per fatality was 412,359 tons or 2.43 fatalities per million tons mined. Texas has been free from serious mine disasters.

FATALITIES IN TEXAS COAL MINES, BY PRINCIPAL CAUSES, DURING 5 YEARS 1909 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	16	64.00	0.67
Mine cars and locomotives	2	8.00	.09
Gas and dust explosions			
Explosives	2	8.00	.09
Miscellaneous	3	12.00	.13
Shaft	1	4.00	.04
Surface	1	4.00	.04
Total, 5 years	25	100.00	1.06

Since 1903, practically one-half of the men in the State have been employed on an 8-hour basis. Tables 40 and 41 have been compiled for comparative purposes. It will be noted that the employees of Texas worked 2,101 hours per year. The fatality rate for the period 1903 to 1913, inclusive, except 1909, based on the actual number of employees, is 1.08 per 1,000 men employed, and based on the 2,000-hour days becomes 1.05. This rate may be readily compared with rates of other States by referring to Table 41. The tables of statistics for the State follow:

NUMBER OF HOURS TO THE WORKING DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN TEXAS.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, or 10 hours per day.	Total number of men employed
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	3	71	6	1,185	6	573	541	2,370
1904	7	1,624	2	91	12	971	235	2,921
1905	11	1,442	3	[b] 125	13	1,135	306	3,008
1906	10	1,817	.....	.....	8	703	528	3,048
1907	5	1,453	1	60	16	2,202	512	4,227
1908	16	2,351	1	50	21	1,759	240	4,400
1909[c]	.....	.....	.....	.....	.....	.....	.....	4,196
1910	20	2,302	1	70	17	1,536	289	4,197
1911	16	3,007	3	179	18	1,649	145	4,980
1912	20	2,908	1	40	19	1,789	390	5,127
1913	19	2,727	8	525	11	1,299	550	5,101

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.
[b] Including daymen who work 10 hours.
[c] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN TEXAS AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day. (all employees.)	Total hours per year.	Number of 2,000-hour workers.	Fatalities.	
					Total.	Per 1,000, 2,000-hour workers.
1903	242	21,922	5,305,124	2,653	.....	.....
1904	220	25,636	5,639,920	2,820	.....	.....
1905	238	26,765	6,370,070	3,185	.....	.....
1906	227	26,318	5,974,186	2,987	.....	.....
1907	244	38,792	9,465,248	4,733	.....	.....
1908	254	39,008	9,908,032	4,954	.....	.....
1909	.....	.....	.....	.....	.....	.....
1910	234	37,007	8,659,638	4,329	7	1.62
1911	226	43,462	9,822,412	4,911	8	1.63
1912	230	45,024	10,355,520	5,177	2	.39
1913	253	44,481	11,253,693	5,626	4	.71

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN TEXAS.[a]

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899	185	2,775	15	1907	270	1,610	6
1900	135	2,740	20	1908	169	338	2
1901	113	226	2	1909	80	4,800	60
1902	50	50	1	1910	1,776	108,230	61
1903	1,055	24,460	23	1911	60	300	5
1904	55	585	11	1912	238	1,724	7
1905	25	375	15	1913	.....	.....	.....
1906	1,260	9,245	7	1914	221	693	3

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 130.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN TEXAS, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.

[Figures for total production and all items below lines in various columns selected from Mineral Resources, U. S. Geol. Survey. Figures in column 4 compiled from State mine inspectors' reports. Figures in columns 5, 6, and 7, and averages in columns 9 and 10, prior to 1900, calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial ax or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1884–1888	490,000																				
1889	128,216	$2.65	543					(a)	236												
1890	184,440	2.53	674					241	274	1.14											
1891	172,100	2.40	787					225	219	.97											
1892	245,690	2.32	871					208	282	1.36											
1893	302,206	2.28	996					251	303	1.21											
1894	420,848	2.32	1,062					283	396	1.40											
1895	484,959	1.88	1,642					171	295	1.73											
1896	544,015	1.65	1,953					187	279	1.49											
1897	639,341	1.52	1,766					220	362	1.65		1.8								5	
1898	686,734	1.66	2,130					245	322	1.31		2.2								5	
1899	883,832	1.51	2,410					256	367	1.43											
1900	968,373	1.63	2,844					246	340	1.38											
1901	1,107,953	1.72	3,051					264	363	1.38		2.0								8	
1902	901,912	1.64	2,369					267	381	1.43		2.8								8	
1903	926,759	1.62	2,380					242	389	1.61		3.1			6	2				8	
1904	1,195,944	1.66	2,921					220	409	1.86		2.8			6		3			9	
1905	1,200,684	1.64	3,008					238	399	1.68		1.9			5		3			8	
1906	1,312,873	1.66	3,048					227	431	1.90		1.7			9		3			12	
1907	1,648,069	1.69	4,227					244	390	1.60		2.2			10		3			13	
1908	1,895,377	1.80	4,400					254	431	1.70		.8			6					6	
1909	1,824,440	1.72	4,196	4	0.95	2.19	456,110	(a)	435	(a)		.9			2	6	3			11	42
1910	1,892,176	1.67	4,197	7	1.67	3.70	270,311	234	451	1.93		1.1			8	6				14	43

1911	1,974,593	1.66	4,980	8	1.61	4.05	246,824	226	397	1.76	31.7	3.6	10.3	54.4	12	.....	3	.....	.....	15	45
1912	2,188,612	1.67	5,127	2	.39	.91	1,094,306	230	427	1.86	47.0	4.8	12.8	35.4	18	.....	3	.....	.....	21	45
1913	2,429,144	1.77	5,101	4	.78	1.65	607,286	253	476	1.88	61.5	4.2	25.2	9.1	20	.....	3	1	.....	24	47
Total	26,649,290	.....	.....	25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (1909–1913)	2,061,793	.....	4,720	5.00	1.06	2.42	412,359	236	437	1.85	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	2,323,773	1.69	4,635	11	2.37	4.73	211,252	237	501	2.11	72.5	1.2	26.3	.....	9	.....	2	2	.....	13	53

a Not reported.

TABLE 131.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN TEXAS, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE, DURING THE CALENDAR YEARS 1909 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pip s.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1909	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
1910	4	.....	1	.....	.....	.....	.....	1	.....	.....	.....	1	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7
1911	5	.....	1	.....	.....	2	.....	.....	.....	.....	.....	.....	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8
1912	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	1	.....	.....	.....	.....	.....	1	1
1913	2	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
1914	4	2	1	1	.....	1	.....	.....	.....	.....	.....	1	10	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	11

UTAH.

AREA AND DISTRIBUTION OF COAL FIELDS.

The coal-bearing areas of Utah comprise about 10,570 square miles, which are roughly divisible into three fields. The Wasatch field is the largest, and includes parts of Carbon, Emery, Grand, Uinta, and Wasatch counties. The next largest field is in the southern part of the State, and occupies the larger part of Garfield, Iron, and Kane counties. The other field is in Summit County, in northern Utah, and is relatively unimportant, although mining operations at Coalville have been carried on since 1870. The greatest amount of development has been in Carbon and Emery counties, Carbon County producing about 90 per cent of the coal mined in the State. The principal districts in Carbon County are Sunnyside, Kenilworth, Castlegate, Pleasant Valley, Spring Canyon, and Hiawatha-Black Hawk.

CHARACTER OF COAL BEDS.

The coal and the associated rocks in the Wasatch field have been subjected locally to serious folding and displacements, but in general the deformation has been uniform, resulting in regular structure and low dips. In western Carbon County and in Emery County the coal-bearing rocks are highly folded and cut by numerous faults, which render mining expensive and uncertain. But in the eastern part of the developed field the coal either lies nearly flat or dips only 3° to 7°.

The beds as a rule are thinner in the eastern than in the western part of the field. The coal in two beds, both of which are mined, in the Sunnyside district is about 14 feet thick, whereas in some of the western districts, as at Kenilworth and Hiawatha, the coal of a single bed ranges from 15 to 20 feet thick.

The coal beds in general are not uniform in thickness over large areas and in many places are known to be very lenticular. Rolls and "horsebacks" are common in some districts and in many places the latter oftentimes cut out a considerable part of the coal bed.

The southern coal field has never been exploited on a commercial scale, but the coal ranges in thickness from 4 to 8 feet.

MINING METHODS.

Coal was first mined on a commercial scale in Utah in 1870, when 5,800 tons was produced. The production in 1913 was 3,254,828 tons, and in 1914, 3,103,036 tons was mined. Most of the mines are opened by drifts, entries, or slopes, and the coal is mined by the room-and-pillar method. The principal mines are worked on the double-entry system and at one of the typical mines the rooms are 24 feet wide by 400 feet long, separated by 40-foot pillars. Wherever

the coal extends 7 to 9 feet in thickness the excess is left on the roof and is taken down only when the pillars are drawn. Most of the mines are comparatively dry and the coal yields considerable dust when mined. The State mining law requires extensive sprinkling systems in such mines and most of the operators rigidly observe the law. Coal is rarely shot from the solid and is usually undercut (by machine or hand pick) or sheared before being shot. Electric shot-firing systems are in common use.

Coal-mining machines were first introduced into Utah in 1896 and in 1913 there were 50 machines in operation. During 1913 the machine-mined coal equaled 19.2 per cent, coal mined by hand-pick methods equaled 74.2 per cent, and that shot from the solid equaled 4.2 per cent.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

An act of Congress approved March 3, 1891, authorized the President of the United States to appoint a mine inspector for each Territory in which the aggregate annual production of coal exceeded 1,000 tons. Under the provisions of this law the first mine inspector for Utah was appointed August 23, 1892. Section 15 of the act provided that a full and written report of every fatal accident should be made to the mine inspector within 10 days after such death should occur. Annual reports for fiscal years ending June 30 were rendered to the Secretary of the Interior. Utah was admitted as a State in January, 1896, and under a law approved April 5, 1896, the first State inspector was appointed April 6. The State inspection law covered all coal and hydrocarbon mines employing more than six men, and the inspector was required to examine all such mines at least quarterly, and to render an annual report to the governor. Mine operators were required to report to the inspector every fatal accident within 10 days after the accident, and every nonfatal accident involving disability for one week or more. An act approved March 20, 1911, authorized the employment of a deputy inspector and repealed the provision of the previous laws limiting the inspection service to mines employing more than six men.

All accidents reported to the inspector by mine operators are published in the inspector's annual report, but only those involving disability for at least 30 days are classified as serious accidents.

ACCIDENTS.

Tables 132 and 133 show the number of men employed, the production of coal, and the number of fatalities as compiled from the best records available. The State mine inspectors' reports show fatal accidents back to 1892, and are complete from that year to

date. The total number of men killed during the period 1892 to 1913, representing 22 years, was 355 or 9.25 fatalities per 1,000

FATALITIES IN UTAH COAL MINES, BY PRINCIPAL CAUSES, DURING THE YEARS 1892 TO 1913, INCLUSIVE.

Causes.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	95	26.76	2.48
Mine cars and locomotives	25	7.04	.65
Gas and dust explosions [a]	205	57.75	5.34
Explosives [b]	5	1.40	.13
Miscellaneous	7	1.97	.18
Shaft	3	.84	.08
Surface	15	4.23	.39
Total, 22 years	355	100.00	9.25

[a] Includes Winter Quarters mine disaster at Scofield, May 1, 1900, in which 200 men were killed by a powder and dust explosion, representing 56.34 per cent of the fatalities, or 5.21 per 1,000 for the 22-year period.
[b] See footnote [a].

COAL-MINE ACCIDENTS IN UTAH IN WHICH 5 OR MORE MEN WERE KILLED.

Date	May 1, 1900.
Name of mine	Winter Quarters Nos. 1 and 4.
Location of mine	Schofield.
Nature of accident	Powder and mine explosion.
Number killed	200.

men employed, of which number 57.75 per cent was due to gas and dust explosions. This includes the explosion at the Winter Quarters mine in 1900, in which 200 were killed at one time. This one disaster represents 56.34 per cent of the total fatalities during the 22-year period. Falls of roof represent 26.76 per cent, or 2.48 fatalities per 1,000 men employed. The quantity of coal produced per fatalitity was 89,252 tons, or 11.20 fatalities per million tons of coal mined.

Since 1903, the mines have been operated on an 8-hour basis, and for comparison with States having 9-hour and 10-hour working days, Tables 40 and 41 have been compiled. It will be noted that during the period 1903 to 1913, except 1909, the men were employed 2,109 hours per year. The fatality rate based on the actual number of employees is 4.15 per 1,000, whereas, when reduced to the uniform basis of 2,000-hour workers, it becomes 3.93, which compares favorably with the rate in Ohio, where the rate on the same basis is 3.94. Similar comparisons with other States may be made by reference to Table 41. The tables of statistics for the State follow.

NUMBER OF HOURS TO THE WORKING DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN UTAH.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, or 10 hours per day.	Total number of men employed
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	12	158	4	1,747	3	9	11	1,925
1904	15	1,356	2	5	1	2	11	1,374
1905	13	1,352			2	6	3	1,361
1906	12	1,554	1	2	1	3	13	1,572
1907	16	2,046					157	2,203
1908	17	2,620			1	2	42	2,664
1909[b]								3,014
1910	20	3,049					4	3,053
1911	21	3,056					390	3,446
1912	22	3,326	1	2				3,328
1913	23	4,063	2	95				4,158

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN UTAH AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day (all employees).	Total hours per year.	Number of 2,000-hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	248	17,176	4,259,648	2,130	7	3.29
1904	294	11,012	3,237,528	1,619	9	5.56
1905	247	10,903	2,693,041	1,347	7	5.20
1906	288	12,597	3,627,936	1,814	4	2.21
1907	258	17,781	4,587,498	2,294	5	2.18
1908	227	21,358	4,848,266	2,424	5	2.06
1909						
1910	260	24,428	6,351,280	3,176	18	5.67
1911	236	27,958	6,598,088	3,299	13	3.94
1912	285	26,626	7,588,410	3,794	19	5.01
1913	273	33,359	9,107,007	4,554	17	3.73

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN UTAH.

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899				1907	148	592	4
1900				1908			
1901	754	23,055	30	1909			
1902				1910			
1903	350	9,800	28	1911	208	624	3
1904				1912			
1905	6	6	1	1913	5	1,300	260
1906				1914	150	1,800	12

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 132.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN UTAH, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.

[Figures for total production and all items below horizontal lines in various columns selected from Mineral Resources, U. S. Geol. Survey. Figures in column 4 and items above horizontal lines in columns 2, 3, and 21 from State mine inspectors' reports. Figures in columns 5, 6, and 7, and averages in columns 9 and 10 prior to 1900, calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial ax or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1870–1887	1,383,689																				
1888	258,961	$2.10	500						518												
1889	236,651	1.59	551					(a)	429												
1890	318,159	1.74	429					289	742	2.57											
1891	371,045	1.80	621					(a)	597												
1892	361,013	1.56	646	2	3.10	5.54	180,507	230	559	2.43											
1893	413,205	1.48	576	0				226	717	3.17											
1894	431,550	1.40	671	1	1.49	2.32	431,550	199	643	3.23											
1895	471,836	1.31	670	1	1.49	2.12	471,836	203	704	3.47											
1896	418,627	1.20	679	2	2.95	4.78	209,314	202	617	3.05		0.2								1	9
1897	521,560	1.19	704	2	2.84	3.83	260,780	204	741	3.63											12
1898	593,709	1.27	739	3	4.06	5.05	197,903	243	803	3.30											11
1899	786,049	1.27	743	0				265	1,058	3.99											
1900	1,147,027	1.26	1,308	209	159.79	182.21	5,488	248	877	3.54											
1901	1,322,614	1.26	1,712	8	4.67	6.05	165,327	259	773	2.98		1.1								13	
1902	1,574,521	1.14	1,826	8	4.38	5.08	196,815	259	862	3.33		4.8								13	
1903	1,681,409	1.20	1,925	7	3.64	4.16	240,201	248	873	3.52		4.5			13					13	
1904	1,493,027	1.30	1,374	9	6.55	6.03	165,892	294	1,087	3.70		2.3			7		2			9	
1905	1,332,372	1.35	1,361	7	5.14	5.25	190,339	247	979	3.96											
1906	1,772,551	1.36	1,572	4	2.54	2.26	443,138	288	1,128	3.92		.1			1		1			2	
1907	1,947,607	1.52	2,203	5	2.27	2.57	389,521	258	884	3.43		.1			3	2				5	
1908	1,846,792	1.69	2,664	5	1.88	2.71	369,358	227	693	3.05											
1909	2,266,899	1.66	3,014	15	4.98	6.62	151,127	(a)	752	(a)											23
1910	2,517,809	1.68	3,053	18	5.90	7.15	139,878	260	825	3.17		1.0			7					7	22

1911	2,513,175	1.69	3,446	13	3.77	5.17	193,321	236	729	3.09	79.3	2.8	7.7	10.2	5	2	.....	.....	7	25
1912	3,010,149	1.67	3,328	19	5.71	6.30	138,745	225	906	3.18	93.0	3.8	3.1	.1	5	6	.....	.....	13	23
1913	3,264,828	1.65	4,168	17	4.09	5.22	191,460	273	783	2.87	74.2	19.2	4.6	2.0	8	7	38	.....	80	27
Total	34,252,834	.....	.....	355	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (1892–1913)	1,440,197	.....	1,744	16.14	9.25	11.20	89,253	254	836	2.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	3,108,036	1.59	4,112	22	5.35	7.09	141,047	210	755	3.60	63.6	30.4	5.9	.1	.....	9	59	.....	68	24

a Not reported.

TABLE 133.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN UTAH, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE DURING THE CALENDAR YEARS 1892 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.								Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22					
1892[a]	1					1							2														2
1893																											0
1894	1												1														1
1895		1											1														1
1896	1												1						1					1	2		2
1897	1	1											2														2
1898	2		1										3														3
1899																											0
1900	3			4	[b] 200	1						1	209														209
1901	4	3	1										8														8
1902	5		2										7						1					1	2		7
1903	3	2				1							6											1	1		7
1904	4		2									2	8			1		1									[c] 9
1905	2	1	1										4	1				1					2		2		7
1906	4												4														4
1907	3		1	1									5														5
1908	2	1	2										5														5
1909	7	6	2										15														15
1910	6	4	3			1						1	15						3						3		18
1911	5	5	2										12									1			1		13
1912	5	9	2										16											1	1		17
1913	3		6			1		1				1	11	1				1	3	1			1		5		17
1914	9		6					1		1			17								2	2		1	5		22

[a] Sept. 28 to Dec. 31.
[b] Probably originated by an explosion of powder magazine underground.
[c] Inspector's report gives detailed description of 9 fatalities, while one table in his report shows 10 giving no details.

VIRGINIA.

AREA AND DISTRIBUTION OF COAL FIELDS.

The coal-bearing area of Virginia comprises about 1,550 square miles in the Appalachian region, 200 square miles in the Brushy Mountain fields, and 150 square miles in the Atlantic Coast region. Of the latter, the larger part is in the Richmond Basin. This basin extends in a north and south direction through parts of Goochland, Henrico, Powhatan, and Chesterfield counties. It is about 30 miles long, with a maximum width of 10 miles, and its eastern edge is about 13 miles from Richmond. There are also one or two other isolated fields in the Atlantic coast region, but mining in these has been of little importance.

The Brushy Mountain fields include long narrow strips of coal-bearing rocks nearly across the State. These rocks are of lower Carboniferous age and are some of the oldest coal-bearing strata known in this country. Some of the coal is of the semianthracite rank.

The Appalachian region includes a large area in the southwestern part of the State, with the principal mines in Wise, Russell, Tazewell, and Lee counties. More than one-half of the coal mined in the State comes from Wise County. The coal-bearing rocks lie in a broad, flat, synclinal trough lying between the southeastern edge of the coal field and Pine Mountain. In the middle of the trough the beds are generally flat, except where they are disturbed by small folds and faults. On the edges of the trough the beds are strongly tilted, in some places even standing vertical.

CHARACTER OF COAL BEDS.

The coal in the Richmond Basin is a bituminous coking coal. The coal beds are steeply inclined and are 4 to 30 feet thick, and in a number of places have been cut by intrusions of diabase, producing natural coke. It has been estimated by Shaler and Woodworth that at a distance of one mile from the outcrop the depth of the beds is 2,500 feet, and it is possible that the beds may extend to a depth of 4,000 feet. The coal beds are broken by faults that make systematic mining difficult.

The coal beds in the Brushy Mountain fields range from 3 to 12 feet in thickness, but the beds contain many partings of shale which make mining expensive and the products of the mines difficult to market. Although desultory mining has been done on these coal beds for a long time, only a little coal has reached the market.

In the main bituminous field the coal beds are much more numerous and valuable. In Lee County 12 beds of coal are of workable

thickness, ranging from 2½ to 6 feet thick. In the Big Stone Gap district the most important coal bed is the Imboden, which ranges from 4 to 13 feet in thickness. There are also a number of beds from 4 to 8 feet thick lying above the Imboden.

On Toms Creek the Upper Banner coal, ranging from 5 to 8 feet thick, is the most important bed. This bed has a shale roof and a hard shale floor.

In Dickenson County the coal beds below the Gladeville sandstone are thin, but above that sandstone 10 beds are recognized, which range in thickness from 2 to 12 feet. The Lower Bolling bed is 4 feet thick with shale roof and clay floor. The Glamorgan bed is 4½ feet thick with shale roof and shale floor. The Pardee bed is about 9½ feet thick.

MINING METHODS.

Coal was first mined in the Richmond Basin in 1750. In 1789 regular shipments were made. Production records begin with 1822 with 5,400 tons. The larger mines are opened by slopes and vertical shafts, the latter being 400 to 500 feet deep. In the earlier days colored labor was employed under the supervision of English and Welsh miners, and the mining systems were largely adapted from English practices. In recent years Hungarian and colored labor is employed, largely under the direction of local or Pennsylvania managers. With the development of the southwestern Virginia field the Richmond Basin remained practically dormant after 1883. Renewed activity has prevailed during the last 4 years.

As in West Virginia, the room-and-pillar method of mining prevails largely throughout the Appalachian region with practically all of the mines opened by drift entries. In 1887 there were only 8 mining machines in operation, but in 1913 there were 187 machines, producing 47.6 per cent of the coal; 19.7 per cent was mined by hand, and 32.6 per cent shot off the solid. The production per man in 1913 was 964 tons.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

The mine-inspection service of Virginia was established in accordance with an act approved March 13, 1912, applying to all coal mines in which five or more persons were employed in a period of 24 hours. The appointment of the inspector was vested in the commissioner of the bureau of labor and industrial statistics, to whom the inspector was required to render annual reports for years ending June 30. Mine operators were required to report to the inspector all accidents

causing loss of life or serious personal injury, stating the cause of such accident, and the inspector, if he deemed it necessary from the facts reported, was required to visit the scene of the accident and render such assistance and advice as he deemed necessary for the future safety of the men.

No rules have been adopted by the Bureau of Labor as to what constitutes a serious injury such as the law requires shall be reported to the inspector, but all accidents of which the inspector receives notice are included in his annual report to the commissioner.

In 1915 one coal-mine inspector was employed.

ACCIDENTS.

Tables 134 and 135 show the production of coal beginning with 1822, the number of employees beginning with 1888, and the number of fatalities from 1909 to date. Although Virginia was one of the first States to produce coal, yet systematic records of accidents in that State have not been kept until recent years. There have been a number of serious mine explosions, extending as far back

FATALITIES IN VIRGINIA COAL MINES, BY PRINCIPAL CAUSES, DURING THE YEARS 1909 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	131	52.19	3.33
Mine cars and locomotives	32	12.75	.81
Gas and dust explosions	25	9.96	.63
Explosives	10	3.98	.25
Miscellaneous	34	13.55	.86
Shaft	1	.40	.03
Surface	18	7.17	.46
Total, 5 years	251	100.00	6.37

COAL-MINE ACCIDENTS IN VIRGINIA IN WHICH 5 OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Nature of accident.	Number killed.
1839 Mar. 18	Black Heath	Near Richmond	Mine explosion	40
1854 ———	Chesterfield	do	do	19
1855 ———	Midlothian	Coalfield	do	55
1876 May 20	do	do	do	8
1882 Feb. 3	do	do	do	32
1884 Mar. 13	Laurel	Pocahontas	do	112
1901 Nov. 14	Pocahontas	do	Mine fire and explosion	9
1901 Nov. 22	do	do	Mine fire	8
1906 Oct. 3	do	do	Mine explosion	35
1907 Mar. 16	Bond and Bruce	Tacoma	do	11
1910 Dec. 14	Greeno	do	do	8
1911 Jan. 20	Carbon Hill	Carbon Hill	do	5
1912 Jan. 16	do	do	Dynamite explosion	5
1912 July 16	Old Dominion No. 1	do	Mine explosion	8

as 1839, as shown in the accompanying list. During the five years, 1909 to 1913, for which continuous records are available, there have been 251 fatalities, representing 6.37 fatalities per 1,000 men employed. The quantity of coal produced per fatality was 138,644 tons, or 7.21 fatalities per million tons of coal mined. Of the total number of fatalities during the 5-year period, 52.19 per cent was due to falls of roof-and-pillar coal, 12.75 per cent to mine cars and locomotives, and 9.96 per cent to gas and dust explosions.

Practically all of the men employed in and about the coal mines in Virginia are on a 10-hour basis, hence to permit comparisons with States on the 8-hour or the 9-hour basis, Tables 40 and 41 have been compiled. The number of hours worked per man a year in Virginia is 2,447 as compared with 2,132 hours in West Virginia, and 1,495 hours in Ohio. In order that true comparisons may be made with reference to the hazard of the mining industry, the time element has been taken into consideration and rates worked out on the basis of the number of 2,000-hour workers, as shown in Tables 40 and 41. Based on the actual number of employees, the rate for the 4 years 1910 to 1913 is 6.74 per 1,000. This reduced to the basis of 2,000-hour workers becomes 5.26 per 1,000, as compared with 5.18 for West Virginia, and 3.94 for Ohio. Table 41 shows figures for the other States worked out on a similar basis, so that comparisons may be readily made. The tables of statistics for the State follow.

NUMBER OF HOURS TO THE WORKING DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN VIRGINIA.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, or 10 hours per day.	Total number of men employed
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	2	250	4	21	21	5,032	305	5,608
1904	2	256	6	372	24	4,092	445	5,165
1905	2	522	7	591	25	3,999	618	5,730
1906	6	105	5	727	31	4,294	5	5,131
1907	.....	.....	7	849	42	5,791	30	6,670
1908	2	112	10	802	32	5,214	80	6,208
1909[b]	.....	.....	.....	.....	.....	.....	.....	6,191
1910	1	189	10	1,021	45	5,710	344	7,264
1911	2	43	4	33	52	6,929	1,102	8,107
1912	2	24	3	41	49	8,181	432	8,678
1913	1	32	8	302	49	8,743	85	9,162

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN VIRGINIA AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day (all employees).	Total hours per year.	Number of 2,000-hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	267	55,254	14,752,818	7,377	.....	.....
1904	238	50,321	11,976,398	5,988	.....	.....
1905	241	55,047	13,266,327	6,633	.....	.....
1906	250	50,368	12,592,000	6,296	.....	.....
1907	241	65,821	15,862,861	7,931	.....	.....
1908	200	60,974	12,194,800	6,097	.....	.....
1909	.....	.....	.....	.....	.....	.....
1910	241	70,897	17,086,177	8,543	57	6.67
1911	261	79,849	20,840,589	10,420	68	6.53
1912	251	86,259	21,651,009	10,826	75	6.93
1913	280	91,169	25,527,320	12,764	24	1.88

TABLE 134.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN VIRGINIA, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.

[Figures for total production and all items below horizontal lines in various columns selected from Mineral Resources, U. S. Geol. Survey. Figures in column 4 beginning with 1909 compiled from State mine inspectors' reports. Figures in columns 5, 6, and 7, and averages in columns 9 and 10 prior to 1900, calculated. Figures in italics represent incomplete fatality records.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial ax or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1822–1887	14,567,029			*266*																	
1888	1,073,000	$1.00	2,400					(a)	447												
1889	865,786	.93	1,523					(a)	568												
1890	784,011	.75	1,295					296	605	2.04											
1891	736,399	.83	820					246	898	3.65											
1892	675,205	.86	836					192	808	4.21											
1893	820,339	.84	961					253	854	3.38											
1894	1,229,083	.76	1,635					234	752	3.21											
1895	1,368,324	.63	2,158					225	634	2.82											
1896	1,254,723	.68	2,510					198	500	2.53											
1897	1,528,302	.67	2,344					213	652	3.06		21.2								8	
1898	1,815,274	.59	1,855					230	979	4.26		13.5								8	
1899	2,105,791	.62	1,960					252	1,074	4.26		23.1			8					8	
1900	2,393,754	.89	3,631					239	659	2.76		9.7								9	
1901	2,725,873	.86	4,152	*17*				279	657	2.35		8.6								6	
1902	3,182,993	.80	3,912					293	814	2.78		4.2								11	
1903	3,451,307	.96	5,608					267	615	2.30		2.4				10				10	
1904	3,410,914	.86	5,165					238	660	2.77		7.2			3	15				18	
1905	4,275,271	.88	5,730					241	746	3.10		9.3			10	25				35	
1906	4,254,879	.98	5,131	*35*				250	829	3.32		10.0			10	27				37	
1907	4,710,895	1.02	6,670	*11*				241	706	2.93		16.7			26	51				77	
1908	4,259,042	.91	6,208					200	686	3.43		24.3			14	71				85	
1909	4,752,217	.89	6,191	27	4.36	5.68	176,008	(a)	768	(a)		27.9			21	82	4			107	62
1910	6,507,997	.90	7,264	57	7.85	8.76	114,175	241	896	3.72		35.1			14	118	4	6		142	63

1911	6,864,667	.91	8,107	68	8.39	9.91	100,951	261	847	3.25	27.2	37.1	35.6	0.1	.....	121	.....	35	.....	156	61
1912	7,846,638	.96	8,678	75	8.64	9.56	104,622	251	904	3.60	11.5	40.3	47.7	.....	5	128	1	51	.....	185	61
1913	8,828,068	1.01	9,162	24	2.62	2.72	367,836	280	964	3.44	19.7	47.6	32.6	.1	4	106	1	76	.....	187	60
Total	96,287,781	.....	.....	580	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (1909–1913)	6,959,917	.....	7,880	50.20	6.37	7.21	138,644	259	883	3.41	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	7,959,535	1.01	9,183	27	2.94	3.39	294,798	235	867	3.69	18.0	51.4	30.5	0.1	4	75	5	98	.....	182	63

[a] Not reported.

TABLE 135.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN VIRGINIA, [a] WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE, DURING THE CALENDAR YEARS 1909 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1909	16	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	11	27	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	27
1910	35	.....	1	.....	10	.....	.....	3	.....	3	.....	2	54	.....	.....	.....	.....	.....	1	.....	.....	.....	2	.....	3	57
1911	35	.....	18	5	.....	.....	.....	2	.....	.....	.....	.....	60	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	4	8	68
1912	33	.....	9	10	.....	10	.....	4	.....	1	.....	.....	67	1	.....	.....	.....	1	3	1	.....	.....	1	2	7	75
1913	11	1	4	.....	.....	.....	.....	4	.....	.....	1	3	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	24
1914	12	1	1	.....	.....	.....	.....	1	.....	.....	.....	.....	15	1	1	.....	.....	2	5	5	.....	.....	.....	.....	10	27

[a] Figures for 1909 are from Mineral Resources, U. S. Geol. Survey; 1910, 1911, and 1912 from reports of mine operators as received by the Bureau of Mines.

WASHINGTON.

AREA AND DISTRIBUTION OF COAL FIELDS.

The coal fields of Washington comprise an area of about 1,800 square miles in the northwestern part of the State. They may be grouped into four fields, as follows: North Puget Sound, including Whatcom and Skagit counties; south Puget Sound, including King and Pierce counties; Roslyn Basin, in Kittitas County; and the southwestern field, including Lewis and Cowlitz counties. King, Kittitas and Pierce counties are the principal producers.

The north Puget Sound field extends from the coast south of Bellingham northeastward to the foot of Mount Baker. It is the south limb of a great syncline. The coal beds dip to the northwest at varying angles, ranging from 35° near the coast to 90° at Cokedale and 45° at Glacier. The quality of the coal ranges from coking bituminous coal at Cokedale and Blue Canyon to anthracite at Glacier.

The south Puget Sound field is characterized by a series of parallel folds, usually in a north-south direction. The principal mines at Wilkeson and Carbonado are on the west slope of an anticline, where there are a number of overthrust faults. The structure in this field is complicated by folding and faulting and the intrusion of igneous rocks.

The Roslyn field, in Kittitas County, is a more regular basin, with a slight pitch to the southeast. The dip of the coal-bearing rocks varies from 10° to 20°, and the basin is free from faults.

The southwestern field is in general a broad, flat basin, but on the east side, next the Cascade Range, the coal beds are badly covered by lava flows. Here the coal is of low rank, being classed generally as the lowest grade of subbituminous coal.

CHARACTER OF COAL BEDS.

The coals of Washington vary from lignite through semibituminous to bituminous coking coal. In a number of the districts the coal produces a large amount of slack or fine coal when mined.

Near Bellingham the coal bed that is now worked is 14 feet thick, whereas at Cokedale there are beds 20 feet thick. Gas is prevalent in these mines. The Blue Canyon bed has an average thickness of 7 feet, and at Glacier it is about 6 feet thick, but badly crushed and distorted.

The coal beds in the South Puget Sound field are more numerous, but the strata are so disturbed that coal beds can seldom be identified from mine to mine, even though the properties are contiguous and in some cases the mine workings connect. The center of production in King County is about Black Diamond. The principal beds here are the Upper McKay, which ranges from 4 feet 4 inches to 4 feet 9

inches, and the Lower McKay, which is 4 feet 7 inches to 6 feet 3 inches in thickness. At New Castle there are four productive beds, varying from 4 to 12 feet in thickness, some of which have been worked down the dip to a depth of about 2,000 feet. At Renton there are two beds, varying from 7½ to 8 feet in thickness. The most important producing area in Pierce County includes the mines on Carbon River from Wilkeson on the north to Montezuma on the south. At Wilkeson there are three coal beds, averaging each about 6 feet thick. At Carbonado at least 10 coal beds, which range in thickness from 2 feet to more than 8 feet, have been worked. The Wingate bed, about 5 feet thick, is the best in the mine. The Carbonado mine has considerable gas, especially on the west side of Carbon River.

In Kittitas County the mines are gaseous, one disastrous explosion occurring during 1910, in which 10 men lost their lives. Another explosion occurred in 1902. At Roslyn coal is being mined from beds 4 feet 6 inches thick from a shaft 604 feet deep. The roof consists of shale. At Clealum, in the same district, coal is being mined from a bed 4 feet 2 inches thick at a depth of 250 feet.

MINING METHODS.

The coal beds are faulted and upturned in many sections, so that it is necessary to mine coal from steeply inclined seams. The mines are opened by shafts, slopes, and drifts. In the Roslyn field the beds are very dry and require sprinkling to prevent the accumulation of dust. The double-entry room and pillar systems of mining are used. At Carbonado the mines are opened by slopes and drifts, some of which extend nearly 2 miles into the mountain side.

A number of the larger collieries in Washington have opened their mines by slopes and the coal is mined by the pillar-and-breast system, about 90 per cent of the coal being extracted. In the northern field the coal beds are opened by shafts and drifts and in some cases the coal seams are gaseous.

In 1896 there were three mining machines in use, producing only 3 per cent of the coal. The number of machines remained about the same until 1909, when there were 18 machines, and in 1913 there were 63 machines, producing 7.2 per cent of the total coal. Shooting off the solid is used for more than one-third the total production.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

An act approved November 28, 1883, effective January 1, 1884, authorized the governor of the Territory of Washington to appoint an inspector of coal mines for all mines employing more than 10 men. In addition to rendering an annual report to the governor, the inspector was required to make a special report on all accidents

causing loss of life or serious bodily injuries. Operators were required to notify the inspector and coroner of all fatal accidents, and upon such notice an investigation was conducted to determine the cause of the accident. The act of February 4, 1886, required operators to notify the inspector of all serious accidents as well as fatal accidents.

On February 2, 1888, an act was approved by which the Territory was divided into two inspection districts, with an inspector for each district appointed by the governor. The State legislature enacted a law which was approved March 5, 1891, relating to the inspection of coal mines, but the requirement as to the reporting of fatal and serious accidents was not changed. The inspectors were appointed by the governor upon the recommendation of an examining board, and were required to file annual reports with the secretary of state before February 1, covering the previous calendar year.

The act of March 6, 1897, provided that the inspection law should apply to all coal mines employing 10 or more men, but that operators of mines enploying less than 10 men should notify the inspector as soon as 10 men were employed.

On March 5, 1907, a law was approved providing one mine inspector for the entire State until there are 60 mines in operation, and dividing the State into districts, containing not less than 10 nor more than 60 mines each, and an inspector for each district, as soon as the number of operating mines in the State exceeds 60. An act approved March 13, 1911, authorized the State mine inspector to appoint, with the consent of the governor, a deputy inspector, who should hold office during the pleasure of the State inspector.

Prior to 1912 it was the practice of the operators to report only those injuries causing at least 30 days' disability, but since that year, when the workmen's compensation law became effective, the operators have reported all injuries resulting in disability for 5 days or more and these are published in the inspector's annual reports. Serious injuries are those resulting in 30 days' disability, all others being considered slight injuries.

In 1915 the inspector was assisted by one deputy.

ACCIDENTS.

Tables 136 and 137 show the production of coal, the number of men employed, and the fatalities in coal mines as compiled from the reports of the United States Geological Survey and the State mine inspectors' reports. Complete records of fatalities from the mine inspectors' reports are available from 1889 to 1913, a period of 25 years. During this time there were 640 fatalities, representing a rate of 6.14 fatalities per 1,000 men employed. The amount of coal produced per death was 93,606 tons, or 10.68 fatalities per

FATALITIES IN WASHINGTON COAL MINES, BY PRINCIPAL CAUSES, DURING THE YEARS 1889 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	182	28.44	1.75
Mine cars and locomotives	81	12.65	.78
Gas and dust explosions	195	30.47	1.87
Explosives	32	5.00	.30
Miscellaneous	102	15.94	.98
Shaft	13	2.03	.12
Surface	35	5.47	.33
Total, 25 years	640	100.00	6.14

FATALITIES DUE TO THE DIP OR PITCH OF COAL SEAMS IN WASHINGTON MINES, 1905 TO 1912, INCLUSIVE.[a]

Cause of accident.	1905	1906	1907	1908	1909	1910	1911	1912
Coal or rock sliding down pitch	3	1	4	2	1	1	2	2
Timber sliding down pitch	.....	.....	4	1	.....	.....	.....	.....
Runaway cars, and men falling from cars or skips	2	7	3	5	1	3	5	.....
Cars on haulage planes	.....	2	.....	.....	.....	.....	1	.....
Falling down slopes or chutes	.....	.....	.....	1	2	2	3	3
Suffocated by gas outburst	.....	1	.....	.....	2	.....	.....	.....
Total	5	11	11	9	6	6	11	5
All fatalities	12	22	36	25	39	43	27	14

[a] Compiled from State mine inspector's reports.

COAL-MINE ACCIDENTS IN WASHINGTON IN WHICH 5 OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Nature of accident.	Number killed.
1892 May 10	Roslyn	Roslyn	Mine explosion	45
1894 Aug. 24	Franklin	Franklin	Mine fire	37
1895 Apr. 8	Blue Canyon	Lake Whatcom	Mine explosion	23
1899 Dec. 9	Carbon Hill No. 7	Carbonado	do	31
1900 Aug. 21	Issaquah No. 4	Issaquah	Smoke from burning air shaft.	5
1902 Oct. 1	Lawson	Black Diamond	Mine explosion	11
1904 Dec. 7	No. 5	Burnett	do	17
1907 Apr. 26	Morgan	Black Diamond	do	7
1909 Oct. 3	Northwestern	Roslyn	do	10
1910 Nov. 6	Lawson	Black Diamond	do	16
1915 Nov. 16	Northwestern	Ravensdale	do	31

million tons of coal mined. During this period there have been 10 mine disasters in which 5 or more men have been killed at one time, making a total of 202 fatalities. Of the total number of fatalities during this 25-year period 30.47 per cent was due to gas and dust explosions; 28.44 per cent to falls of roof and coal; and 12.65 per cent to mine cars and locomotives.

Practically all of the mines in Washington are operated on an 8-hour basis, and for purposes of comparison with 9 and 10 hour States, Tables 40 and 41 have been compiled. The number of hours worked per year per man is 2,023. The fatality rate based on the actual number of employees is 4.64, as compared with 4.58 when

reduced to the equivalent of 2,000-hour workers. Table 41 gives similar data for all of the States, so that comparisons of one State with another may be readily made.

NUMBER OF HOURS TO THE WORKING-DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN WASHINGTON.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, or 10 hours per day.	Total number of men employed.
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	5	342	17	2,245	6	2,180	.....	4,768
1904	24	4,152	4	70	.....	.....	1,065	5,287
1905	18	3,644	1	28	8	353	740	4,765
1906	29	4,179	4	106	2	13	231	4,529
1907	41	5,594	1	5	.....	.....	346	5,945
1908	39	4,665	1	20	.....	.....	799	5,484
1909[b]	.....	.....	.....	.....	.....	.....	.....	5,992
1910	40	6,129	.....	.....	.....	.....	185	6,314
1911	45	5,642	.....	.....	.....	.....	1,594	7,236
1912	42	5,344	.....	.....	2	50	125	5,519
1913	52	5,794	.....	.....	.....	.....	.....	5,794

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN WASHINGTON AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day (all employees).	Total hours per year.	Number of 2,000-hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	285	44,751	12,754,035	6,377	25	3.92
1904	243	43,431	10,553,733	5,277	31	5.87
1905	227	39,594	8,987,838	4,494	12	2.67
1906	266	36,595	9,734,270	4,867	22	4.52
1907	273	47,911	13,079,703	6,540	37	5.66
1908	202	44,691	9,027,582	4,514	25	5.54
1909	.....	.....	.....	.....	.....	.....
1910	256	50,697	12,978,432	6,489	43	6.63
1911	225	59,482	13,383,450	6,692	27	4.03
1912	226	44,377	10,029,202	5,014	14	2.79
1913	260	46,352	12,051,520	6,026	22	3.65

On account of the coal beds being badly upturned, necessitating working on steep pitches or dips, there is an unusual percentage of accidents due to coal, rock, or timber sliding down from a working face, from cars getting loose and running down an incline, and from men falling down chutes or slopes. About 30 per cent of the fatalities belong to this group, as shown in the accompanying table. In nearly all of the States, the bituminous coal beds are comparatively flat, but Washington is an exception in this respect. Outside of certain fields in Oklahoma and Colorado, and the anthracite fields in eastern Pennsylvania, there is not a district where the coal beds are as steeply inclined as in Washington. The tables of statistics for the State follow:

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN WASHINGTON.[a]

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899				1907	484	8,544	18
1900	100	3,000	30	1908	226	67,800	300
1901				1909	123	2,300	19
1902				1910	101	303	3
1903	200	6,600	33	1911	2,099	22,215	10
1904	365	25,020	69	1912	807	31,347	39
1905				1913	1,239	60.145	49
1906				1914	459	25,410	55

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 136.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN WASHINGTON, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.

[Figures for total production and all items below horizontal lines in various columns selected from Mineral Resources, U. S. Geological Survey. Figures in column 4 and items above horizontal lines in columns 2, 3, and 21 are from State mine inspectors' reports. Figures in columns 5, 6, and 7 and averages in columns 9 and 10 prior to 1900 calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial ax or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1860–1884	1,759,683	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1885	380,250	.....	840	3	3.57	7.89	126,750	.....	453	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1886	423,525	.....	840	4	4.76	9.44	105,881	.....	504	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1887	772,601	.....	1,520	2	1.32	2.59	386,301	.....	508	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1888	1,215,750	(a)	(a)	(a)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1889	1,030,578	$2.32	2,657	6	2.26	5.82	171,763	(b)	388	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1890	1,263,689	2.71	2,206	7	3.17	5.54	180,527	270	573	2.12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1891	1,056,249	2.31	2,447	14	5.72	13.25	75,446	211	432	2.05	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1892	1,213,427	2.28	2,564	55	21.45	45.33	22,062	247	473	1.91	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1893	1,264,877	2.31	2,757	9	3.26	7.12	140,542	241	459	1.90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1894	1,106,470	2.33	2,662	50	18.78	45.19	22,129	207	416	2.01	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1895	1,191,410	2.16	2,840	39	13.73	32.73	30,549	224	420	1.88	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1896	1,195,504	2.00	2,622	8	3.05	6.69	149,438	221	456	2.06	.....	0.3	.....	.....	.....	.....	.....	.....	.....	3	.....
1897	1,434,112	1.94	2,739	7	2.56	4.88	204,873	236	524	2.22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1898	1,884,571	1.78	3,145	11	3.50	5.84	171,325	270	599	2.22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1899	2,029,881	1.78	3,330	45	13.51	22.17	45,108	259	610	2.36	.....	.7	.....	.....	2	.....	.....	.....	.....	2	21
1900	2,474,093	1.90	3,670	31	8.45	12.53	79,809	289	674	2.33	.....	.4	.....	.....	.....	.....	.....	.....	.....	2	24
1901	2,578,217	1.66	4,545	27	5.94	10.47	95,490	276	567	2.05	.....	.3	.....	.....	.....	.....	.....	.....	.....	4	19
1902	2,681,214	1.72	4,404	34	7.72	12.68	78,859	275	609	2.21	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	23
1903	3,193,273	1.69	4,768	25	5.24	7.83	127,731	285	670	2.35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	32
1904	3,137,681	1.63	5,287	31	5.86	9.88	101,216	243	593	2.44	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	32
1905	2,864,926	1.79	4,765	12	2.52	4.19	238,744	227	601	2.65	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	47
1906	3,276,184	1.80	4,529	22	4.86	6.72	148,917	266	723	2.72	.....	.4	.....	.....	.....	.....	1	.....	.....	1	48
1907	3,680,532	2.09	5,945	37	6.22	10.05	99,474	273	619	2.27	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	52
1908	3,024,943	2.21	5,484	25	4.56	8.26	120,998	202	552	2.73	.....	.7	.....	.....	4	.....	.....	.....	.....	4	43

1909	3,602,263	2.54	5,992	39	6.51	10.83	92,366	(a)	601	(a)	.....	1.4	.....	15	3	.....	.....	18	45
1910	3,911,899	2.50	6,314	43	6.81	10.99	90,974	256	620	2.42	.....	1.4	.....	10	.....	.....	.....	10	49
1911	3,572,815	2.29	7,238	27	3.73	7.56	132,326	225	494	2.20	62.9	5.3	27.6	4.2	.....	.....	23	23	50
1912	3,360,932	2.39	5,519	14	2.54	4.17	240,067	226	609	2.69	59.3	7.7	32.8	.2	.....	.....	56	56	48
1913	3,877,891	2.38	5,794	22	3.80	5.67	170,268	260	669	2.57	54.7	7.2	37.8	.3	1	.....	61	63	53
Total	64,458,440	.....	.....	649	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (1880–1913)	2,386,605	.....	4,167	25.00	6.14	10.68	83,666	248	575	2.33	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	3,064,820	2.20	5,805	17	2.93	5.55	180,284	191	528	2.76	42.8	10.7	47.1	.4	46	.....	1	25	72	58

a Report not available.

b Not reported.

TABLE 137.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN **WASHINGTON**, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE, DURING THE CALENDAR YEARS 1885 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22			
1885												3	3													3
1886			1			2							3	1				1								4
1887	1											1	2													2
1888 [a]																										
1889	1			1								4	6													6
1890	1		1	2		1	1					1	7													7
1891	1	2	2			1						5	11	1			1	2						2	2	14
1892	3		3	46								1	53		1		1	1							1	55
1893	4		3										7				1	1		1					1	9
1894	2	1	4		4						37	1	49											1	1	50
1895		1	1	26		1					4	3	36							1	2				3	39
1896	5	1				1						1	8													8
1897 [b]	2		2									2	6											1	1	7
1898	3	2	4									1	10											1	1	11
1899	4	4	1	1	31	1						2	44											1	1	45
1900	12	1	1	4			3				5	2	28							1	1			1	3	31
1901	9	5	4	2		2					1		23	2	1			3	1						1	27
1902	7	5	5		11	2							30	1	1			2		1				1	1	34
1903	10	4	6			2							22	1				1	1	1					2	25
1904	5	2	2		17	3	1						30											1	1	31
1905	6	1	3			1						1	12													12
1906	6	1	9	1				1					16			1		1	2		1				3	20
1907	10	1	2	10		5		3				1	32						3		1			1	5	37
1908	13	1	8	1				1				1	25													25
1909	9	4	1	14		3		4				2	37						1		1				2	39
1910	8	2	4		18	4		3				2	41						1				1		2	43
1911	6	4	8			2		2			1		23	1				1	2		1				3	27
1912	3	3	3			1		3					13				1	1								14
1913	7		4	5	1	2		1				1	21			1		1							1	22
1914	6	2	3	1		3		1					16						1						1	17

[a] Report not available.

[b] Figures are from Feb. 2 to Dec. 31.

WEST VIRGINIA.

AREA AND DISTRIBUTION OF COAL FIELDS.

The coal fields of West Virginia occupy all of the area on the Western slope of the Appalachian Mountains. The entire area of the State is 24,022 square miles, of which an area of approximately 17,000 square miles is coal-bearing. Thirty counties are important producers. The 6 counties heading the list, in the order of their production in 1913, are McDowell, Fayette, Marion, Harrison, Kanawha, and Logan, each of which mined more than 4,000,000 tons of coal.

There are seven important fields, the three in the northern part of the State being (1) Fairmont field, including Harrison and Monroe counties; (2) Elk Garden (Piedmont), or Upper Potomac field, including Mineral, Grant, and Tucker counties; (3) Phillipi field, including Preston, Barbour, and Randolph counties. The four fields in the southern part of the State are as follows: (1) New River field, including Fayette and Raleigh counties; (2) Kanawha field, including Kanawha and parts of Boone and Putnam counties; (3) Pocahontas field, including McDowell and Mercer counties, W. Va., and Tazewell County, Va.; and (4) Big Sandy field, which is a continuation of the Kanawha district into Logan and Mingo counties.

In general the coal beds and the associated sandstones, limestones, and shales of the West Virginia fields dip northwestward toward the axis of the great Appalachian trough, which passes through the northwestern part of the State from the southwest corner of Pennsylvania to Wayne County on Big Sandy River. Notwithstanding the general regularity of this great trough, the southeastern side, especially in northern West Virginia, is affected by a number of anticlinal folds trending in the same direction as the axis of the great trough. These smaller folds cause the dips in places to be much steeper than the normal, and on the southeast flank of the arch, to be toward the southeast. This is well illustrated in the synclinal trough in Preston County east of the Chestnut ridge anticline.

CHARACTER OF COAL BEDS.

All of the West Virginia coal is bituminous or semibituminous, the majority of which is of high rank.

The coal increases in rank from west to east across the State, the semibituminous coals being limited to small fields along the margin of the area. These fields of semibituminous coal are Pocahontas, New River, and Upper Potomac (Georges Creek). These coals are preeminently steam coals, going into the market as "smokeless," but they also are used to a limited extent in coke making.

The most important coal in the Fairmont and Elk Garden districts is the Pittsburgh (Elk Garden or 14-foot) bed, with an average

thickness of 8 feet 6 inches, of which 7 feet is usually mined. The Waynesburg and Sewickley coal beds occur in the Fairmont district, but are little worked. They vary in thickness from 5 to 10 feet. The Elk Garden district also contains the Thomas or Upper Freeport, 2½ to 3½ feet thick, and the Davis (Upper Kittanning or "Six-Foot") bed, varying from 4 to 11 feet in thickness. In the Kanawha district, the most important beds are "No. 2 Gas" and the Eagle (soft coking coal), varying in thickness from 3 to 5 feet, and the Coalburg and No. 5 (splint coal), varying from 4 to 6 feet thick.

In the New River field the principal beds are the Sewell, varying in thickness from 3½ to 5 feet; Fire Creek, averaging 3 feet, and the Beckley, varying from 4 to 6 feet. The Pocahontas field produces coal from the "No. 3" bed, which is 4 to 11 feet thick, averaging about 6 feet. In recent years considerable development work has been done on the "No. 4" and also on the Sewell bed.

MINING METHODS.

The earliest records showing coal production of West Virginia are for 1863,[a] during which year West Virginia became a State, and 444,648 short tons was mined. This tonnage has gradually increased until in 1913 the production amounted to 71,308,982 short tons.

As the majority of the beds outcrop at various places, nearly all of the mines are opened by drifts or slopes, few shafts being necessary for mining operations. The room-and-pillar method of mining is extensively used. In 1913, there were 1,479 locomotives in use in the mines, of which 1,365 were electric, 46 steam, 40 compressed air, and 28 gasoline.

Mining in the Elk Garden district began in 1881. In 1891, there were 8 machines used in the State of West Virginia, and this number has gradually increased until in 1913 there were 2,541 machines in use. The average production per machine in 1913 was 15,116 tons. About one-half of the machines used are of the chain-breast type. Of the total amount of coal mined, 55.3 per cent in 1913 was mined by machines; 43.6 per cent was mined by hand, and only 0.8 per cent was shot off the solid.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

An act approved March 11, 1879, authorized the judge of any circuit court in any county to appoint a mine inspector for such county, upon a petition signed by 100 voters showing that any coal mine employing more than 10 men was not sufficiently ventilated. Inspectors so appointed were required to report in writing on the first day of every term of said court the condition of all such mines and whether

[a] Prior to 1863 the production of coal in what is now West Virginia was reported as of Virginia.

any employee had been injured, and the cause of such accident. By an act approved February 26, 1883, the inspection service was placed under the jurisdiction of a State mine inspector, and applied to all coal mines employing 15 or more miners. The inspector was required to render an annual report to the governor, showing number of employees, and number of persons killed or injured. The act of February 20, 1890, divided the State into two inspection districts and authorized the governor to appoint a mine inspector for each district, each inspector to render annual reports to the governor for years ending June 30. A chief mine inspector was authorized by the act of February 17, 1897, assisted by four district inspectors, who rendered monthly reports to the chief inspector. The department of mines was created by the act of February 25, 1905, and placed in charge of the chief mine inspector. The act of February 27, 1907, changed the title of chief mine inspector to that of chief of the department of mines, and the inspection law was extended to cover all mines employing five or more men. Various laws have increased the number of district inspectors until in 1914 there were twelve such inspectors.

ACCIDENTS.

Tables 138 and 139 show the production of coal and number of men employed, together with the fatalities in the coal mines in the State. The fatalities have been compiled from the reports of the State mine inspectors and are based on a calendar year, and do not, therefore, necessarily agree with the inspectors' figures published for fiscal years. During the period from 1885 to 1913, for which continuous complete records are available, there were 4,748 fatalities, representing 4.97 fatalities per 1,000 men employed. The amount of coal produced per fatality during this period was 160,635 tons or 6.23 fatalities per million tons of coal mined. During this period there have been 30 mine disasters, in each of which 5 or more men were killed.

FATALITIES IN WEST VIRGINIA COAL MINES, BY PRINCIPAL CAUSES, 1885 TO 1913 INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	2,452	51.64	2.57
Mine cars and locomotives	557	11.73	.58
Gas and dust explosions	1,036	21.82	1.09
Explosives	155	3.27	.16
Miscellaneous	202	4.25	.21
Shaft	67	1.41	.07
Surface	279	5.88	.29
Total, 29 years	4,748	100.00	4.97

COAL-MINE ACCIDENTS IN WEST VIRGINIA IN WHICH 5 OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Nature of accident.	Number killed.
1886 Jan. 31	Newburg	Newburg	Mine explosion	39
1894 Nov. 20	Blanche	Standard	Powder and coal-dust explosion.	8
1900 Mar. 6	Red Ash	Red Ash	Mine explosion	46
1900 Nov. 2	Berryburg	Berryburg	Powder-smoke explosion.	15
1901 May 15	Chatham	Farmington	Mine explosion	10
1902 Sept. 15	Algoma No. 7	Algoma	do	17
1902 Sept. 22	Stafford	Stafford	do	6
1905 Feb. 26	Grapevine	Wilcoe	Powder and mine explosion.	6
1905 Mar. 18 to Mar. 19	Rush Run and Red Ash.	Red Ash	Mine explosion	24
1905 Apr. 20	Cabin Creek	Kayford	Powder explosion	6
1905 Nov. 4	Tidewater	Vivian	Powder and mine explosion.	7
1905 Dec. 4	Horton	Horton	Mine fire	7
1906 Jan. 4	Coaldale	Coaldale	Mine explosion	22
1906 Jan. 18	Detroit	Detroit	do	18
1906 Feb. 8	Parral	Parral	do	23
1906 Mar. 22	Century No. 1	Century	Powder and mine explosion.	23
1907 Jan. 26	Lorentz	Penco	Powder explosion	12
1907 Jan. 29	Stuart	Stuart	Mine explosion	84
1907 Feb. 4	Thomas No. 25	Thomas	do	25
1907 May 1	Whipple	Scarboro	do	16
1907 Dec. 6	Monongah Nos. 6 and 8.	Monongah	do	361
1908 Jan. 30	Backman	Hawk's Nest	do	9
1908 Dec. 29	Lick Branch	Switchback	do	50
1909 Jan. 12	do	do	do	67
1909 Mar. 31	Echo	Buery	Dynamite explosion	6
1910 Dec. 31	Lick Fork	Thacker	Mine cars	10
1911 Apr. 24	Ott No. 20	Elk Garden	Mine explosion	23
1911 Nov. 18	Bottom Creek	Vivian	do	18
1912 Mar. 26	Jed	Jed	do	81
1912 July 11	Panama	Moundsville	do	8
1914 Apr. 28	Eccles Nos. 5 and 6	Eccles	do	181
1914 June 30	Cindrella	Cindrella	Suffocated by fumes from fire in fan house.	5
1915 Feb. 6	Carlisle	Carlisle	Mine explosion	21
1915 Mar. 2	Layland No. 3	Layland	do	112
1915 Nov. 30	Boomer No. 2	Boomer	do	23

Of the total number of fatalities during the 29-year period, 51.64 per cent were due to falls of roof and coal; 21.82 to gas and dust explosions; and 11.73 to mine cars and locomotives. Fatalities due to explosives were comparatively few, representing only 3.27 per cent of the total. The percentage of fatalities due to explosives in Oklahoma for a period of 21 years was 15.77; in Ohio, for a period of 30 years, 7.02; and in Illinois, for a period of 29 years, 13.47.

Since 1903, both the 9-hour and the 10-hour day have prevailed throughout the State, there being more than 50 per cent of the men employed on a 10-hour basis. For a true comparison with other States where an 8-hour or a 9-hour day prevails, the time element has been taken into consideration, and Tables 40 and 41 have been compiled on the basis of the actual number of men employed over a 10-year period, 1903 to 1913, inclusive, except 1909; also on the basis of 2,000-hour workers. The fatality rate during the 10-year period based on the actual number of employees is 5.53 per 1,000, and reduced to the equivalent of 2,000-hour workers becomes 5.18. The number of hours worked a year per man in West Virginia is 2,132, as compared with 1,495 for Ohio. The Ohio rate based on the

NUMBER OF HOURS TO THE WORKING DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN WEST VIRGINIA.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, and 10 hours per day.	Total number of men employed.
	Number of mines.	Men employed.	Number of mines.	Men employed.	Number of mines.	Men employed.		
1903	45	1,685	110	10,311	212	22,260	7,298	41,554
1904	53	1,870	137	11,855	271	30,751	2,759	47,235
1905	49	3,532	161	14,387	251	25,731	4,739	48,389
1906	43	2,510	190	15,208	308	31,531	1,711	50,960
1907	35	1,879	156	13,386	322	32,005	11,759	59,029
1908	30	1,242	180	14,426	403	39,550	1,643	56,861
1909[b]								55,433
1910	49	4,671	133	12,950	494	50,432	610	68,663
1911	49	4,242	126	11,477	527	49,996	1,085	66,800
1912	47	4,959	119	10,815	535	50,944	1,530	68,248
1913	29	1,864	369	35,123	365	37,094	705	74,786

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN WEST VIRGINIA AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day (all employees).	Total hours per year.	Number of 2,000-hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	210	394,561	82,857,810	41,429	147	3.55
1904	197	453,996	89,437,212	44,719	149	3.33
1905	209	457,700	95,659,300	47,830	212	4.43
1906	220	487,661	107,285,420	53,643	277	5.16
1907	230	561,387	129,119,010	64,560	736	11.40
1908	185	550,057	101,760,545	50,880	310	6.09
1909						
1910	228	663,728	151,329,984	75,665	329	4.35
1911	221	646,954	142,976,834	71,488	341	4.77
1912	266	660,217	175,617,722	87,809	381	4.34
1913	234	708,304	165,743,136	82,872	337	4.07

actual number of employees is 2.94, and reduced to the equivalent number of 2,000-hour workers becomes 3.94, so that the difference between the figures for the two States is not so great as would appear when the rates are based on the actual number of employees. Similar comparisons in these details may be made with other States by referring to Table 41. The tables of statistics for the State follow:

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN WEST VIRGINIA.[a]

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899	3,468	76,829	22	1907	617	9,749	16
1900	1,883	44,318	24	1908	501	71,992	144
1901	1,438	45,161	31	1909	1,919	29,585	15
1902	18,129	1,362,054	75	1910	1,630	13,985	9
1903	1,524	63,212	41	1911	1,510	16,483	11
1904	3,682	167,343	45	1912	12,165	606,588	50
1905	462	12,111	26	1913	8,800	377,405	43
1906	4,101	123,724	30	1914	9,330	466,768	50

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 138.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN WEST VIRGINIA, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.

[Figures for total production and all items below horizontal lines in various columns selected from Mineral Resources, U. S. Geol. Survey. Figures in column 4 and all items above horizontal lines in columns 2, 3, 8, and 20 compiled from State mine inspectors' reports. Figures in columns 5, 6, and 7, and averages in columns 9 and 10 prior to 1900, calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial ax or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1863–1879	13,404,944	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1880	1,829,844	.....	3,726	.....	.....	.....	.....	.....	491	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1881	1,680,000	.....	4,470	.....	.....	.....	.....	.....	376	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1882	2,240,000	.....	5,214	.....	.....	.....	.....	.....	430	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1883	2,335,833	.....	6,394	20	3.13	8.56	116,792	.....	365	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1884	3,360,000	.....	6,351	(a)	.....	.....	.....	.....	529	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1885	3,369,062	$1.00	7,292	23	3.15	6.83	146,481	.....	462	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1886	4,005,796	.95	7,262	47	6.47	11.73	85,230	(b)	552	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1887	4,881,620	.95	8,456	11	1.30	2.25	443,784	230	577	2.51	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1888	5,496,800	1.10	9,700	28	2.89	5.09	196,386	(b)	567	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1889	6,231,880	.82	9,778	14	1.43	2.25	445,134	(b)	637	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(b)	.....
1890	7,394,654	.84	12,236	29	2.37	3.92	254,988	227	604	2.66	.....	.....	.....	.....	.....	.....	.....	.....	.....	(b)	.....
1891	9,220,665	.80	14,227	47	3.30	5.10	196,184	237	648	2.73	.....	.....	.....	.....	.....	.....	.....	.....	.....	8	.....
1892	9,738,755	.80	14,867	45	3.03	4.62	216,417	228	655	2.87	.....	.....	.....	.....	.....	.....	.....	.....	.....	(b)	.....
1893	10,708,578	.77	16,524	62	3.75	5.79	172,719	219	648	2.96	.....	.....	.....	.....	.....	.....	.....	.....	.....	(b)	.....
1894	11,627,757	.75	17,824	79	4.43	6.79	147,187	186	652	3.51	.....	.....	.....	.....	.....	.....	.....	.....	.....	(b)	.....
1895	11,387,961	.68	19,159	64	3.34	5.62	177,937	195	594	3.05	.....	.....	.....	.....	.....	.....	.....	.....	.....	(b)	.....
1896	12,876,296	.65	19,078	65	3.41	5.05	198,097	201	675	3.36	.....	3.4	.....	.....	.....	.....	.....	.....	.....	25	.....
1897	14,248,159	.63	20,504	77	3.76	5.40	185,041	205	695	3.39	.....	4.7	.....	.....	.....	.....	.....	.....	.....	47	.....
1898	16,700,999	.61	21,607	90	4.17	5.39	185,567	218	773	3.55	.....	7.4	.....	.....	.....	.....	.....	.....	.....	86	.....
1899	19,252,995	.63	23,625	95	4.02	4.93	202,663	242	815	3.37	.....	9.3	.....	.....	55	99	.....	.....	.....	154	.....
1900	22,647,207	.81	29,163	150	5.14	6.62	150,981	231	777	3.36	.....	15.1	.....	.....	.....	.....	.....	.....	.....	327	.....
1901	24,068,402	.87	30,935	133	4.30	5.53	180,965	219	778	3.55	.....	20.0	.....	.....	.....	.....	.....	.....	.....	403	.....
1902	24,570,826	1.00	35,500	134	3.77	5.45	183,364	205	692	3.38	.....	23.4	.....	.....	.....	.....	.....	.....	.....	579	.....

1903	29,337,241	1.17	41,554	147	3.54	5.01	199,573	210	706	3.36	.....	27.9	.....	.....	358	430	.....	.....	.....	788	.....
1904	32,406,752	.88	47,235	149	3.15	4.60	217,495	197	686	3.48	.....	29.4	.....	.....	410	491	.....	.....	.....	901	.....
1905	37,791,560	.86	48,389	212	4.38	5.61	178,262	209	781	3.74	.....	33.1	.....	.....	473	628	4	.....	.....	1,105	.....
1906	43,290,350	.95	50,960	277	5.44	6.40	156,283	220	849	3.86	.....	36.0	.....	.....	571	744	7	.....	.....	1,322	.....
1907	48,091,583	.99	59,029	736	12.47	15.30	65,342	230	815	3.54	.....	36.7	.....	.....	617	853	63	.....	.....	1,533	.....
1908	41,897,843	.95	56,861	310	5.45	7.40	135,154	185	737	3.98	.....	39.8	.....	.....	599	899	76	.....	.....	1,574	.....
1909	51,849,220	.86	55,433	336	6.06	6.48	154,313	(b)	935	(b)	.....	40.8	.....	.....	700	1,036	108	.....	.....	1,844	664
1910	61,671,019	.92	68,663	329	4.79	5.33	187,450	228	898	3.94	.....	45.4	.....	.....	680	1,081	199	6	.....	1,966	716
1911	59,831,580	.90	66,800	341	5.10	5.70	175,459	221	896	4.05	46.9	48.7	1.0	3.4	667	1,041	77	253	6	2,044	755
1912	66,786,687	.94	68,248	381	5.58	5.70	175,293	266	979	3.68	46.6	52.3	.7	.4	604	1,217	175	245	12	2,253	742
1913	71,308,982	1.01	74,786	337	4.51	4.73	211,599	234	954	4.08	43.6	55.3	.8	.3	562	1,364	231	363	19	2,539	788
Total	787,543,870	.....	.....	4,768	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(Average 1885–1913)	26,209,767	.....	32,955	163.72	4.97	6.22	160,635	220	798	3.63	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	71,707,626	1.00	78,963	556	7.04	7.75	128,971	201	908	4.52	40.4	58.9	.5	.2	517	1,407	167	460	56	2,607	822

a No report published for 1884.

b Not reported.

TABLE 139.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN WEST VIRGINIA, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE, DURING THE CALENDAR YEARS 1883 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.								Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1883	11	6	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	19	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	20
1884 [a]	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1885	12	4	1	3	.....	.....	.....	.....	.....	.....	.....	.....	20	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	.....	3	23
1886	4	.....	1	39	.....	.....	.....	.....	.....	.....	.....	.....	44	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	2	3	47
1887	9	1	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11
1888	18	5	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	25	1	.....	1	.....	2	.....	.....	.....	.....	1	.....	1	28
1889	7	3	2	.....	.....	.....	.....	.....	.....	.....	.....	1	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	14
1890	18	3	1	.....	.....	3	.....	.....	.....	.....	.....	.....	25	.....	.....	.....	.....	.....	1	.....	.....	.....	1	2	4	29
1891	25	6	6	5	.....	1	.....	.....	.....	.....	.....	.....	43	.....	.....	.....	.....	.....	2	.....	1	.....	1	.....	4	47
1892	23	12	3	.....	.....	5	.....	.....	.....	.....	.....	2	45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	45
1893	35	13	7	.....	.....	.....	.....	.....	.....	.....	.....	2	57	3	.....	.....	.....	3	1	.....	.....	.....	.....	1	2	62
1894	41	11	11	.....	8	.....	.....	.....	1	.....	2	2	76	1	.....	.....	.....	1	2	.....	.....	.....	.....	.....	.....	78
1895	40	8	4	.....	.....	5	.....	.....	.....	.....	.....	3	60	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	4	64
1896	42	5	8	.....	.....	2	.....	.....	.....	.....	.....	4	61	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	3	4	65
1897	47	14	7	1	.....	2	.....	.....	.....	.....	.....	.....	71	1	.....	.....	.....	1	2	.....	.....	.....	2	1	5	76
1898	51	12	13	.....	.....	3	.....	.....	.....	.....	.....	1	80	.....	.....	1	.....	1	4	.....	1	.....	2	2	9	90
1899	51	15	12	3	.....	4	.....	3	.....	.....	.....	1	89	.....	.....	.....	.....	.....	2	.....	.....	1	1	2	6	95
1900	58	7	9	47	.....	19	.....	.....	1	.....	.....	.....	141	.....	.....	.....	.....	.....	7	.....	.....	.....	2	.....	9	150
1901	70	12	14	11	.....	9	.....	.....	.....	1	1	4	122	1	.....	.....	.....	1	8	.....	.....	.....	1	1	10	133
1902	61	16	14	23	.....	5	.....	1	.....	.....	.....	.....	120	5	.....	.....	.....	5	6	.....	.....	.....	.....	3	9	134
1903	79	20	13	2	3	7	.....	2	1	1	.....	2	130	1	.....	.....	.....	1	12	.....	.....	1	1	2	16	147
1904	93	13	16	2	.....	3	.....	3	.....	.....	.....	2	132	2	.....	2	.....	4	10	.....	1	.....	1	1	13	149
1905	99	7	25	7	38	10	.....	.....	2	.....	8	1	197	.....	.....	2	.....	2	6	.....	1	.....	5	1	13	212
1906	108	12	18	26	66	5	.....	6	.....	1	.....	1	243	7	1	2	.....	10	12	.....	2	.....	2	8	24	277
1907	132	17	37	25	461	20	.....	4	1	1	.....	2	700	4	1	.....	.....	5	12	.....	1	.....	2	16	31	736
1908	121	30	39	1	59	11	.....	10	3	1	.....	2	277	10	.....	.....	.....	10	12	4	2	.....	1	4	23	310
1909	142	30	52	4	67	14	.....	11	.....	.....	.....	3	323	1	.....	.....	.....	1	6	2	.....	.....	.....	4	12	336
1910	173	31	55	3	.....	8	.....	20	1	4	.....	1	296	3	.....	11	.....	14	15	.....	1	.....	.....	3	19	329
1911	164	28	55	18	23	3	.....	22	1	4	.....	3	321	2	.....	.....	.....	2	10	3	2	.....	2	1	18	341
1912	176	18	45	8	83	8	.....	21	.....	2	.....	.....	361	.....	.....	2	.....	2	11	3	2	.....	2	.....	18	381
1913	170	30	86	.....	.....	8	.....	17	.....	6	.....	2	319	1	.....	1	.....	2	10	1	2	.....	.....	3	16	337
1914	187	33	73	182	.....	5	.....	29	2	5	5	3	524	2	1	1	.....	4	9	2	1	1	4	11	28	556

[a] No report published.

WYOMING.

AREA AND DISTRIBUTION OF COAL FIELDS.

The coal fields of Wyoming comprise an area of about 25,000 square miles. In addition to this area, in which the coal beds are fairly well known, there are a number of deep basins such as Bighorn Basin, Wind River Basin, and Green River Basin, aggregating 16,000 square miles, in which coal beds are doubtless present, but are at such a depth as possibly to be unavailable.

The most important region in point of quality of coal and quantity produced is the Green River Basin, including the belt of disturbed rocks in Lincoln and Uinta counties. This region comprises about 18,000 square miles underlain by coal-bearing rocks, but an area of only 8,000 square miles contains coal beds that are now accessible. This region includes the Kemmerer and Rock Springs districts, which produce practically all of the high-grade coal of the State. The production of this region in 1913 was about 4,500,000 tons.

The region of next importance is the Powder River region, which has an area of 74,000 square miles. Of this, an area of about 11,000 square miles is believed to be underlain by coal beds more than 3 feet thick. The coal in this field is subbituminous, and Sheridan is the chief center of production.

In the Bighorn, Wind River, and Hanna Basins and in the belt of disturbed rocks in Lincoln and Uinta counties the coal beds are considerably disturbed and in places dip at high angles, but in other fields the dips are low and regular, or the beds are practically flat.

CHARACTER OF COAL BEDS.

The general structure of the Rock Springs district of the Green River field is that of a dome, the axis of which is about 90 miles long extending north and south. The coal beds on the west of this anticlinal axis dip 5° to 30°, whereas those on the east vary from 5° to 10°. There are many normal faults of less than 100 feet in displacement. There are four coal-bearing groups, containing 20 beds 2 to 12 feet thick, aggregating 90 feet at Rock Springs, Sweetwater County, which produced in 1913 about 35 per cent of the State's output.

In the Kemmerer district, Lincoln County, there are three principal coal beds known as the Upper, Main, and Lower Kemmerer beds. These range from 4 to 14 feet in thickness and are generally considered as the best coals in the State. They dip 20° to 25° to the west. This district has the distinction of containing the thickest coal bed that has been mined in the United States. It is 84 feet thick in the old prospect entry, but as the coal slacked badly the mine was abandoned.

In the Powder River field, immediately east of Sheridan, there are 5 coal beds as follows: Healy, 10 to 15 feet thick; Felix, 6 to 30 feet thick; Arvada, 5 to 10 feet thick; Roland, 3 to 7 feet thick; and Smith, 4 to 10 feet thick. South of Sheridan is a small area, known as the Buffalo district, containing the Healy bed, which is about 15 feet thick, and the Walters bed, which is 35 feet thick. These beds are also horizontal. Sheridan County in this field produced 15 per cent of the State's 1913 output.

In the Little Snake River field the coal beds are inclined from horizontal to about 35°. The coal is 3 to 12 feet thick, with shale and sandstone roof.

In the Bighorn Basin the beds dip 3° to 56°, varying from 5 to 10 feet in thickness. Little coal has been mined from this area.

MINING METHODS.

The earliest statistics of coal production in Wyoming are for 1865, when 800 tons of coal was produced. In 1913 the production was 7,393,066 tons.

In most of the mines thus far developed in the Rock Springs district the roof and floor of the coal beds are firm and give little trouble. The majority of the mines are opened by slopes and a few by shafts. The room-and-pillar method of mining is used in coal beds varying from 4 to 8 feet in thickness. In the Rock Springs district a large percentage of the coal is mined by shooting off the solid. There is comparatively little gas in the mines.

In the northern part of the State, in Sheridan County, mines are opened by drifts and the coal is mined by room-and-pillar methods. The coal beds are thicker than in the Rock Springs district, varying from 10 to 19 feet, and in places are 25 to 30 feet thick.

Mining machines have been in use in Wyoming since about 1890. In 1913 there were 195 machines in use, producing 41 per cent of the coal; 36.7 per cent was mined by being shot off the solid; and 21.9 per cent by hand mining. A number of the mines are using electric coal-cutting machines, and haulage is by mules and electricity.

REPORTABLE ACCIDENTS AND ORGANIZATION OF INSPECTION SERVICE.

The inspection of coal mines was placed under the jurisdiction of a Territorial mine inspector by an act approved February 25, 1886, covering all coal mines in which 10 or more men were employed. Operators were required to render to the inspector immediate reports of all fatal and serious accidents. All fatal accidents were to be reported to the county coroner also, and upon such notice an investigation was conducted to determine the cause of the accident. The inspector rendered quarterly reports showing number of accidents

and deaths from injuries, number employed at the mines, etc., and published his report in at least one paper in each county in which there were any coal mines. The act of February 17, 1903, divided the State into two inspection districts and authorized the governor to appoint a mine inspector for each district, the inspector to render quarterly reports of accidents. By the act of February 27, 1909, the inspectors were required, within one week after the examination of each mine, to send a written report of such examination to the governor and also to file with the governor an annual report not later than December 1 of each year. There are no regular deputy or assistant inspectors, but the district inspectors are authorized to appoint temporary deputies to investigate accidents when it is impossible for the district inspectors to be present in person.

Prior to the enactment of the workmen's compensation law, mine operators reported to the inspectors only those injuries resulting in disability to an employee for at least 14 days, and these were published in the inspectors' annual reports. Under the compensation law, which became effective April 1, 1915, all accidents at mines are required to be reported.

ACCIDENTS.

Tables 140 and 141 show the production of coal and number of employees since 1889 to the end of 1913. The fatality records are not so complete, continuous records being available only from 1908 to the end of 1913. During this period of 6 years there were 241 fatalities in and about the coal mines, representing 5.21 fatalities per 1,000 men employed. The production of coal per fatality was 169,801 tons, or 5.89 fatalities per million tons of coal mined. Of the total number of men killed during the 6-year period, 47.30 per cent was due to falls of roof and coal; 27.80 per cent to gas and dust explosions; and 9.13 per cent to mine cars and locomotives.

FATALITIES IN WYOMING COAL MINES, BY PRINCIPAL CAUSES, DURING THE YEARS 1908 TO 1913, INCLUSIVE.

Cause of accident.	Number killed.		
	Total.	Per cent.	Per 1,000 employed.
Underground:			
Fall of roof and pillar (coal, rock, etc.)	114	47.30	2.46
Mine cars and locomotives	22	9.13	.48
Gas and dust explosions	67	27.80	1.15
Explosives	13	5.40	.28
Miscellaneous	17	7.05	.37
Shaft	1	.41	.02
Surface	7	2.91	.15
Total, 6 years	241	100.00	5.21

COAL-MINE ACCIDENTS IN WYOMING IN WHICH 5 OR MORE MEN WERE KILLED.

Date.	Name of mine.	Location of mine.	Nature of accident.	Number killed.
1881 Mar. 4	Almy	Almy	Mine explosion	38
1886 Jan. 13	Almy No. 4	do	do	13
1895 Mar. 20	Red Canyon	Red Canyon	do	60
1901 Feb. 25	Diamondville No. 1	Diamondville	Mine fire	28
1901 Oct. 26	Diamondville	do	Mine explosion	22
1903 June 30	Hanna No. 1	Hanna	Mine explosion and fire.	169
1905 Dec. 1	Diamondville No. 1	Diamondville	Mine explosion	18
1908 Mar. 28	Hanna No. 1	Hanna	do	59
1912 Jan. 20	Kemmerer No. 4	Kemmerer	do	6
1914 Apr. 29	Union Pacific No. 2	Cumberland	Mine cars	5

Since 1881 there have been 11 coal-mine disasters, in each of which five or more men were killed at one time, representing 428 fatalities. A list is given in the accompanying table.

Since 1907 the mines in Wyoming have been operated on an 8-hour basis, and for comparison with States having 9-hour and 10-hour days, the time element has been taken into consideration. The number of hours worked per annum per man in Wyoming for the 10-year period 1903 to 1913, except 1909, was 2,137. The fatality rate during the 5 years 1908, 1910, 1911, 1912, and 1913, for which complete records are available, is 5.38, based on the actual number of employees, whereas if based on the equivalent number of 2,000-hour workers it becomes 5.71. By referring to Tables 40 and 41, comparisons with other States may be readily made. The tables of statistics for the State follow:

NUMBER OF HOURS TO THE WORKING DAY, BY YEARS, IN AND ABOUT THE COAL MINES IN WYOMING.[a]

Year.	8-hour day.		9-hour day.		10-hour day.		Men employed other than 8, 9, or 10 hours per day.	Total number of men employed.
	Number of mines.	Number of men.	Number of mines.	Number of men.	Number of mines.	Number of men.		
1903	2	289	2	583	20	4,024	97	4,993
1904	5	19	1	491	17	5,087	63	5,660
1905	2	8	2	456	26	5,492	21	5,977
1906	2	8	2	25	29	5,500	401	5,934
1907	37	6,382	6	197	.....	.....	66	6,645
1908	51	6,802	.....	.....	2	17	96	6,915
1909 [b]	.....	.....	.....	.....	.....	.....	.....	7,123
1910	41	6,175	.....	.....	.....	.....	1,596	7,771
1911	60	6,571	2	5	.....	.....	1,542	8,118
1912	60	7,807	1	3	.....	.....	226	8,036
1913	56	8,321	2	6	1	4	.....	8,331

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey. [b] Census year.

NUMBER OF HOURS WORKED IN AND ABOUT THE COAL MINES IN WYOMING AND THE FATALITY RATE BASED ON THE NUMBER OF 2,000-HOUR WORKERS.

Year.	Days worked.	Total hours per day (all employees).	Total hours per year.	Number of 2,000 hour workers.	Fatalities.	
					Total.	Per 1,000 2,000-hour workers.
1903	252	48,672	12,265,344	6,133	.....	.....
1914	262	55,008	14,674,096	7,337	.....	.....
1905	236	59,277	13,989,372	6,995	.....	.....
1906	281	58,898	16,550,338	8,275	.....	.....
1907	275	53,413	14,691,325	7,346	.....	.....
1908	217	55,450	12,032,650	6,017	81	13.46
1909	.....	.....	.....	.....	.....	.....
1910	248	63,764	15,813,472	7,907	36	4.55
1911	230	66,491	15,292,930	7,647	32	4.18
1912	238	64,517	15,355,046	7,678	36	4.69
1913	232	66,862	15,465,584	7,733	26	3.36

STATISTICS OF STRIKES AND LOCKOUTS IN AND ABOUT THE COAL MINES IN WYOMING.[a]

Year.	Number of men affected.	Total days lost.	Average number of days lost per man.	Year.	Number of men affected.	Total days lost.	Average number of days lost per man.
1899	.....	.....	.....	1907	1,785	22,060	12
1900	.....	.....	.....	1908	4,658	99,576	21
1901	160	1,120	7	1909	.....	.....	.....
1902	.....	.....	.....	1910	1,196	12,792	11
1903	413	4,130	10	1911	.....	.....	.....
1904	.....	.....	.....	1912	360	3,425	10
1905	192	192	1	1913	.....	.....	.....
1906	231	5,775	25	1914	248	2,727	11

[a] Compiled from annual volumes of Mineral Resources, U. S. Geol. Survey.

TABLE 140.—PRODUCTION, NUMBER OF MEN EMPLOYED, AND NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN **WYOMING**, BY CALENDAR YEARS. ALSO TONNAGE MINED PER MAN, AS WELL AS THE NUMBER AND KIND OF MINING MACHINES IN USE.[a]

[Figures for total production and all items below horizontal lines in various columns selected from Mineral Resources, U. S. Geol. Survey. Figures in column 4, beginning with 1905, compiled from State mine inspectors' reports. Figures in columns 5, 6, and 7 and averages in columns 9 and 10 prior to 1900 calculated.]

Year.	Production (short tons).	Value per ton at mine.	Number employed.	Number killed.			Production per death (short tons).	Days worked.	Average tonnage per man.		Percentage coal mined by—				Number and kind of machines.						Number of mines.
				Total.	Per 1,000 employed.	Per 1,000,000 tons mined.			Per year.	Per day.	Hand.	Machine.	Shot off solid.	Not reported.	Pick.	Chain breast.	Long wall.	Short wall.	Radial ax or post.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1865–1888	10,363,052			*51*																	
1889	1,388,947	$1.26	2,675					(*b*)	519												
1890	1,870,366	1.70	3,272					246	572	2.33											
1891	2,327,841	1.53	3,411					(*b*)	682											34	
1892	2,503,839	1.27	3,133					225	799	3.55											
1893	2,439,311	1.35	3,378					189	722	3.82											
1894	2,417,463	1.31	3,032					190	797	4.19											
1895	2,246,911	1.33	3,449	*60*				184	651	3.54											
1896	2,229,624	1.37	2,937					210	759	3.61		18.8								30	
1897	2,597,886	1.21	3,137					219	828	3.78		21.4								45	
1898	2,863,812	1.28	3,475					242	824	3.40		22.1								48	
1899	3,837,392	1.24	4,697					261	817	3.13		18.1			42	14				56	
1900	4,014,602	1.36	5,332					266	753	2.83		16.3								69	
1901	4,485,374	1.35	5,151	*50*				248	871	3.51		17.9								74	
1902	4,429,491	1.18	5,250	*21*				248	844	3.40		13.1								69	
1903	4,635,293	1.24	4,993	*169*				252	928	3.63		16.9			42	17				59	
1904	5,178,556	1.30	5,660	(*b*)				262	915	3.49		20.4			46	26				72	
1905	5,602,021	1.31	5,977	*18*				236	937	3.97		22.1			49	26	6			81	
1906	6,133,994	1.31	5,934	(*b*)				281	1,034	3.68		21.8			48	34	1			83	
1907	6,252,990	1.56	6,645	*30*				275	941	3.42		21.3			45	33	1			79	
1908	5,489,902	1.62	6,915	81	11.71	14.75	67,777	217	794	3.66		19.5			47	40	1			88	
1909	6,393,109	1.55	7,123	30	4.21	4.69	213,104	(*b*)	898	(*b*)		22.4			85	38	4			127	61
1910	7,533,088	1.55	7,771	36	4.63	4.78	209,252	248	969	3.91		19.5			65	29	4			98	66

1911	6,744,864	1.56	8,118	32	3.94	4.74	210,777	230	831	3.61	29.0	28.9	39.8	2.3	55	*77	1	12	10	155	69
1912	7,368,124	1.58	8,036	36	4.48	4.89	204,670	238	917	3.85	24.6	32.1	43.2	.1	68	77	2	19	13	179	72
1913	7,393,066	1.56	8,331	26	3.12	3.52	284,349	232	887	3.82	21.9	41.3	36.7	.1	61	84	11	27	12	195	61
Total	118,740,918			640																	
Average (1908–1913)	6,890,359		7,716	40.17	5.21	5.89	189,891	232	884	3.81											
1914	6,475,293	1.55	8,117	51	6.28	7.88	126,967	192	798	4.16	23.7	42.2	34.0	.1	56	78	2	48	14	198	56

a Figures in italics represent incomplete fatality records. b Not reported. c Includes 2 cutter-bar machines.

TABLE 141.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN WYOMING, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE, 1908 TO 1914, INCLUSIVE.

Year.	Killed underground.													Killed in shaft.					Killed on surface.							Grand total.
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions (including gas and dust combined).	Explosives.	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burnet, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	
	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16		17	18	19	20	21	22		
1908	6	3	1	.....	59	1	.....	.....	.....	.....	.....	10	80	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1	81
1909	11	9	5	.....	.....	4	.....	.....	.....	.....	.....	.....	29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	30
1910	15	10	3	.....	.....	6	.....	.....	.....	.....	.....	1	35	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	1	36
1911	15	9	4	1	.....	1	.....	.....	.....	.....	.....	1	31	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	32
1912	16	5	5	.....	7	.....	.....	1	.....	.....	.....	.....	34	.....	.....	1	.....	1	1	.....	.....	.....	.....	.....	1	36
1913	13	2	4	.....	.....	1	.....	2	1	1	.....	.....	24	.....	.....	.....	.....	.....	1	.....	.....	.....	1	.....	2	26
1914	22	5	9	.....	.....	4	.....	1	1	.....	1	.....	43	.....	.....	.....	.....	.....	5	.....	2	1	.....	.....	8	51

TABLE 142.—NUMBER OF MEN KILLED IN AND ABOUT THE COAL MINES IN THE UNITED STATES DURING THE CALENDAR YEAR 1915, WITH THE FATALITIES CLASSIFIED ACCORDING TO CAUSE.

State.	Killed underground.													Killed in shaft.					Killed on the surface.							Total by States.	
	Falls of roof (coal, rock, etc.).	Falls of face or pillar coal.	Mine cars and locomotives.	Gas explosions and burning gas.	Coal-dust explosions.	Explosives.[a]	Suffocation from mine gases.	Electricity (shock or burns).	Animals.	Mining machines.	Mine fires (burned, suffocated, etc.).	Other causes.	Total.	Falling down shafts or slopes.	Objects falling down shafts or slopes.	Cages or skips.	Other causes.	Total.	Mine cars and mine locomotives.	Electricity (shock or burns).	Machinery.	Boiler explosions or bursting steam pipes.	Railway cars and locomotives.	Other causes.	Total.	1915	1914
Alabama	21	2	17	5	.....	7	.....	8	.....	.....	.....	.....	60	.....	.....	1	.....	1	.....	.....	1	.....	.....	1	2	63	128
Alaska and California	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	0
Arkansas	5	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	.....	.....	.....	.....	1	.....	1	.....	2	8	11
Colorado	40	1	8	3	.....	.....	2	3	.....	.....	.....	2	59	1	.....	.....	.....	1	.....	.....	2	.....	.....	1	3	63	75
Georgia and North Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	1
Idaho and Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	0
Illinois	45	12	29	20	2	11	1	6	.....	.....	.....	.....	126	.....	1	1	.....	5	.....	.....	1	.....	4	.....	5	136	193
Indiana	17	2	7	2	.....	10	.....	3	.....	.....	.....	.....	41	1	.....	1	.....	2	.....	.....	.....	.....	1	2	3	46	44
Iowa	23	.....	5	.....	.....	1	.....	.....	.....	.....	.....	1	30	1	.....	1	.....	2	.....	.....	1	.....	.....	1	2	34	37
Kansas	10	.....	.....	2	4	6	.....	.....	.....	.....	.....	.....	22	.....	.....	1	.....	1	.....	.....	1	.....	.....	.....	1	24	33
Kentucky	35	3	14	.....	.....	2	.....	5	.....	.....	.....	.....	59	1	.....	1	.....	2	2	.....	.....	.....	.....	1	3	64	61
Maryland	5	.....	1	.....	.....	2	.....	1	.....	.....	.....	.....	9	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1	10	18
Michigan	2	.....	.....	.....	.....	.....	.....	1	.....	2	.....	.....	5	1	.....	.....	.....	1	.....	.....	.....	.....	1	.....	1	7	2
Missouri	4	.....	.....	2	.....	6	1	3	.....	.....	.....	.....	16	.....	1	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	17	19
Montana	7	2	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	11	1	.....	.....	.....	1	1	.....	.....	.....	.....	.....	1	13	8
New Mexico	13	1	3	.....	.....	.....	.....	2	.....	.....	.....	.....	19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19	18
North Dakota	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	3
Ohio	31	8	15	.....	.....	3	.....	4	.....	2	.....	1	64	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	65	64
Oklahoma	5	.....	3	1	2	5	.....	.....	.....	.....	.....	.....	16	1	.....	.....	.....	1	.....	1	.....	.....	1	3	5	22	31
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	1
Pennsylvania (anthracite)	194	67	80	34	.....	79	11	4	1	1	.....	45	516	10	.....	.....	.....	10	28	1	11	2	.....	18	60	586	595
Pennsylvania (bituminous)	204	41	77	30	.....	9	.....	24	2	5	.....	8	400	8	.....	.....	.....	8	10	4	5	.....	.....	11	30	438	402
Tennessee	15	.....	4	.....	.....	3	1	2	.....	.....	.....	.....	25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	25	26
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	1	11
Utah	7	1	.....	.....	.....	.....	.....	1	.....	.....	1	.....	10	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	11	22
Virginia	30	1	8	.....	.....	2	.....	2	.....	.....	.....	3	46	.....	.....	.....	.....	.....	1	1	.....	.....	.....	.....	2	48	27
Washington	5	3	1	.....	31	.....	.....	2	.....	.....	.....	.....	42	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	1	3	45	17
West Virginia	184	12	72	53	112	6	.....	17	.....	2	.....	2	460	2	.....	.....	.....	2	29	2	1	3	4	2	32	494	556
Wyoming	15	4	1	.....	.....	2	.....	1	.....	.....	.....	.....	23	.....	.....	.....	.....	.....	.....	.....	.....	1	1	1	3	26	51
Total, 1915	917	160	347	153	151	155	16	89	3	12	1	62	2,068	31	2	7	.....	40	62	10	26	6	14	42	160	2,266	.....
Total, 1914	985	146	380	332	17	146	14	89	7	20	7	57	2,200	70	5	12	1	88	68	11	26	5	13	43	166	.....	2,454

[a] Includes premature blasts, explosion of misfires, suffocation by gases from explosives, etc.

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Bulletin 116

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FRANKLIN K. LANE, SECRETARY

BUREAU OF MINES

VAN. H. MANNING, DIRECTOR

METHODS OF SAMPLING DELIVERED COAL

AND SPECIFICATIONS FOR THE PURCHASE OF COAL FOR THE GOVERNMENT

BY

GEORGE S. POPE

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METHODS OF SAMPLING DELIVERED COAL, AND TYPES OF SPECIFICATIONS FOR THE PURCHASE OF COAL FOR THE GOVERNMENT.

By GEORGE S. POPE.

INTRODUCTION.

This bulletin is a revision of Bulletin 63 and is published by the Bureau of Mines in order that purchasers of coal for Government, State, municipal, or private use may be informed regarding advances or refinements in sampling coal deliveries and preparing specifications for the purchase of coal.

The purchase of coal by the Government under specifications depending on the heating value of the coal, its content of ash and of moisture, and other considerations, rather than upon the reputation or trade name of the coal, was based on the fuel investigations begun by the Technologic Branch of the United States Geological Survey in 1904. The plan was first adopted by the Treasury Department in 1906. Since then the plan, variously modified in form, but the same in principle, has been gradually adopted by other departments until, at present, of the coal used by the Government, the total value of which approximates $8,000,000 annually, more than half is purchased under specifications. The Government publications dealing with the adoption by the Government of the specification plan, the number of contracts awarded on that basis, and the quality of the coal delivered under such contracts in the several fiscal years covered by the reports are given in publications [a] listed at the end of this bulletin.

Under the authority of acts of Congress making appropriations for analyzing and testing fuels belonging to or for the use of the United States Government, a laboratory is maintained at the headquarters of the Bureau of Mines, Washington, D. C., where samples representing deliveries of coal purchased under specifications for Government use are analyzed and tested.

At this laboratory more than 1,200 samples have been analyzed and tested in one month. With the complete equipment and the efficient force employed, the analytical work has been so perfected that the analyses and heating-value tests of the samples received are as accurate as may be reasonably expected in laboratory work of this nature.

[a] See Bulls. 11, 41, and 119, Bureau of Mines.

One of the serious drawbacks to the general adoption of the specification method for the purchase of coal is the difficulty of obtaining at reasonable cost samples of coal that can be considered fairly representative of the commercial product delivered in wagons, railroad cars, or ships. Therefore the method of taking and preparing samples for shipment to the laboratory has been given fully as much care as the making of the analyses and tests, and a general plan of collecting samples fairly representative of the delivered coal has been evolved through various modifications and improvements based on experience and increased knowledge of the physical and chemical characteristics of the various coals that are purchased by the Government. The method that is in general use by the Government is described in the following pages.

In connection with studies of the coal deposits of the country, of the best methods of preventing waste in mining, and of increasing efficiency in the utilization of coal belonging to or for the use of the Government, geologists and engineers of the United States Geological Survey and of the Bureau of Mines have visited more than 2,500 coal mines scattered through all of the coal-producing States and Territories. From each mine 2 to 8 or more samples were taken, the number depending upon the size of the mine and its output. The analyses and descriptions of the samples collected up to the end of the fiscal year 1913 are published in Bureau of Mines bulletins 22[a] and 85,[b] and those of samples collected in the fiscal years 1914 and 1915 are presented in a bulletin that will soon be published by the bureau.

A study of the analyses of these samples and of the samples taken from cars shipped from a number of the same mines shows that the mine samples are as a rule of higher grade than the average commercial shipments, particularly with respect to containing a lower percentage of ash and having a correspondingly higher heating value. This difference is due to the fact that the Government inspector, proceeding on the basis of what can be done by a good miner, usually removes more of the partings of bone, slate, and other extraneous matter from his mine samples than the average miner does in ordinary practice, the aim of the miner being to get the maximum number of tons past the tipple inspection, as his earnings are based on his output. The average miner, therefore, does not always take as much care as he might in rejecting the impurities. The difference may be caused, too, by the presence of pieces of the mine roof and floor in commercial shipments. The Government inspector can readily

[a] Lord, N. W., and others, Analyses of coals in the United States, with descriptions of mine and field samples collected between July 1, 1904, and June 30, 1910: Bull. 22, Bureau of Mines, 1912, 1129 pp. In two parts.

[b] Fieldner, A. C., Smith, H. I., Fay, A. H., and Sanford, S., Analyses of mine and car samples of coal collected in the fiscal years 1911 to 1913: Bull. 85, Bureau of Mines, 1914, 444 pp.

exclude these from the mine sample, but they often get into the commercial coal as a result of the character of the roof and floor and of the mining methods employed. The efficiency of the tipple inspection and the means employed in rejecting impurities when the coal is loaded into the railroad car are also factors that often largely account for the difference between mine and commercial samples. Most of the samples collected from the mines by the Government inspectors show a higher moisture content than commercial samples, because of the generally moist atmosphere of the mine and the precaution taken to prevent loss of moisture in the collection, preparation, and analysis of mine samples.

When properly taken, the mine samples are of great value, as they indicate the general character of the coal and the uniformity of the coal bed and enable one to determine its probable value for any designated purpose, provided due consideration is given to the character of the partings, the roof, and the floor, and to the possibility of pieces from these being loaded with the commercial output.

The collection of mine samples by the Bureau of Mines and the Geological Survey is done in a systematic manner, according to a prearranged plan, and the same procedure is always followed where circumstances permit. A special outfit for use in collecting mine samples has been developed. The method followed and a description, with illustrations, of the outfit are published in Bureau of Mines Technical Paper 1, entitled "The Sampling of Coal in the Mine."

THEORY OF SAMPLING.

To determine with utmost accuracy the ash content and heating value of a quantity of delivered coal would require the burning of the entire quantity, and special apparatus arranged to measure the total heat liberated, or would require crushing the whole quantity, and reducing it by an elaborate scheme of successive crushings, mixings, and fractional selections to portions weighing approximately 1 gram, the minute quantity which the chemist requires for each determination. Either of these procedures is obviously impracticable if the coal is to be used for the production of heat and power.

The method actually employed is to select portions from all parts of a consignment or delivery of coal and to systematically reduce the gross sample, obtained by mixing these portions, to quantities that the chemist requires for making ash determinations or that can be burned conveniently in the calorimeter, an apparatus for determining the heating value. The gross sample should be so large that the chance admixture of pieces of slate, bone coal, pyrite, or other impurities in an otherwise representative sample will affect but slightly the final results. Increasing the size of the gross sample tends toward accuracy, but the possible increase is limited by the

cost of collection and reduction. In reducing the gross sample by successive crushings and halvings or fractional selections, the object is to procure a small laboratory sample that, upon analysis, will give approximately the same results as the gross sample itself, or, in fact, the entire quantity of coal from which the gross sample was obtained.

THE METHOD OF SAMPLING AS A PART OF COAL SPECIFICATIONS.

The method of sampling because of its importance as a definite commercial procedure, is clearly set forth in the specifications in use by the Government, and is made a part of the contract. In order that there may be uniformity and similarity in specifications used by the different branches of the Federal service for the purchase of coal, the Bureau of Mines has prepared specifications for general use by the Government. These specifications in their present form are the result of development following years of experience and satisfactory use by various Government branches. The specifications printed on pages 46 to 58, are typical of the Federal specifications in use for the fiscal year 1915–16. It is recognized that in general specifications, such as presented, certain requirements have to be of wide application, in order to cover a variety of conditions, not only as to character and quality of coal, but as to type of furnace equipment, size of deliveries, and method of delivering.

PRACTICAL CONSIDERATIONS

MOISTURE.

The specifications that were used for the purchase of coal on the heat-unit basis prior to the fiscal year 1912–13 were on the B. t. u. (British thermal unit) "as received" basis; that is, payment for delivered coal was directly affected by the moisture content of the sample received by the laboratory. This method was based on the assumption that the moisture in the samples collected at the time of weighing and delivery could be preserved with slight loss during the storing and subsequent working down of the gross sample to a quantity convenient for transmittal to the laboratory and in its later treatment in the laboratory. From experiments that have been made and from a large mass of data, it is known that the moisture content of coal does not remain constant, and that the moisture content reported by the laboratory may be as much as 5 to 10 per cent lower than that actually contained in excessively wet or high-moisture coal at the time of weighing.

In one investigation, 254 gross samples were reduced, at the delivery point, to samples weighing approximately 5 pounds each and then the 5-pound samples were divided into two equal parts ("duplicates"), which were placed in mailing cans and sent to the Bureau of Mines for analysis. The moisture contents of the "duplicates" were

presumably identical, but analysis showed that the average difference between the moisture contents of the 254 pairs of "duplicates" was 0.256 per cent and the maximum difference was 3.6 per cent. These figures indicate the moisture differences that may exist even after the gross sample has been reduced to approximately 5 pounds, but they do not show the moisture lost by the gross sample while in storage and while being reduced to 5 pounds. As stated above, the total loss of moisture may be as much as 5 to 10 per cent in high-moisture or excessively wet coals..

As a sample loses moisture, its B. t. u. "as received" value correspondingly rises, with the result that the price for delivered coal determined on the "as received" value is, with rare exceptions, higher than that warranted by the quality of the coal at the time of weighing. As a general statement, payment based on the "as received" B. t. u. value will be higher than warranted, unless the sampling and laboratory work can be carried on under conditions that minimize moisture loss, as under freezing temperatures.

Recognizing the uncertainty involved in taking the moisture determination in the laboratory as representative of the moisture content of the delivered coal and the consequent possibility of payment of a higher price than is warranted, the Bureau of Mines recommends that the heating value in coal specifications be on the "dry-coal" basis.

The fact is recognized that the amount of moisture contained in coal produced from day to day from the same mine, or group of mines working the same bed, is largely accidental, and is a matter over which the buyer and seller have only slight control. However, in order to place a negative value on high-moisture coals and to protect the Government against the delivery of coals containing excessive amounts of moisture, the specifications require the bidders to specify the maximum moisture content in coal offered. This value becomes the standard of the contract.

If coal of uniform B. t. u. "dry-coal" value is delivered on a contract, the contractor receives the advantage on any delivery in which the moisture content approaches the maximum specified, because he is paid for the weight of water contained in the coal in excess of a normal amount, whereas if the coal is very dry, containing less than the normal amount of moisture, the purchaser receives the advantage.

For example, coal is delivered under a contract in which the standards are 14,300 B. t. u. per pound "dry coal," and a maximum moisture content of 3.5 per cent. The heating value of a ton (2,240 pounds) of "dry coal" would be 32,032,000 B. t. u. Assume that the average moisture content of deliveries for a year is 2.5 per cent, then for every 2,240 pounds of "dry coal" having a heating value of 32,032,000 B. t. u., the purchaser is required to pay for 56 pounds

of water at the same rate per ton as for "dry coal," but as this percentage of moisture in average deliveries is inherently a constituent of the coal, it is considered as part and parcel of the coal by both the purchaser and the seller. If the coal delivered contains 3.5 per cent moisture, to procure 32,032,000 B. t. u. "dry coal," the purchaser has to pay 1 per cent more for coal because of the excess water above the normal amount, whereas if the coal contains 1.5 per cent moisture, the purchaser pays 1 per cent less. As the variations in moisture content, 1.5 or 3.5 per cent, are largely accidental, the season of the year being partly responsible for them, it is equitable that the purchaser and seller should share the uncertainty. The purchaser justly has a right, however, to demand that the seller shall guarantee a maximum moisture content, as a means of enabling the purchaser to compare one coal with another, as a guaranty that the seller will observe precautions against delivering coal that is unduly wet, and as a basis for adjusting the price of exceptionally wet coal.

The United States Weather Bureau in its annual reports gives the total precipitations per month and the maximum in 24 hours for different sections of the United States. At Washington, D. C., the greatest rainfall recorded for one month is 5.89 inches, and for 24 consecutive hours is 3.67 inches.

As an example of the effect of a heavy rain on a car of coal in transit, a precipitation of 3 inches of water on a loaded 50-ton car, area of top about 360 square feet, would increase the weight of the coal 5.01 per cent, provided none of the water drained out or evaporated. It is obvious that if this coal is weighed and delivered immediately, special samples for moisture determinations should be collected and prepared at once and sent to the laboratory, as a basis for equitable adjustment of payment on account of the excessive amount of water in the coal. As the weight of the coal was increased by the excess water, there should be a corresponding decrease in the price to be paid.

If a railroad car or a wagon so rained on was not unloaded immediately after weighing and the special moisture samples were not properly collected, prepared, and sent hermetically sealed to the laboratory, it is obvious that the purchaser would pay a higher price than warranted, especially if the car or wagon stood for some time before sampling and some of the water drained out. Further, if the coal was not immediately unloaded and sampled or if the car continued in transit after weighing, then the coal at the top would soon dry; and in either case the effect of the 3-inch rainfall, as indicated by the analysis, might be only a fractional percentage of the moisture contained in the coal at the time of weighing.

The determination of the moisture in coal delivered from stock piles is often of great importance, for the proportion of moisture

contained in the small sizes, which are most abundant near the center of a stock pile and which absorb the rains, and melting snows in districts of heavy snows, may be from 10 to 15 per cent higher than when stocked. It is apparent, therefore, that special moisture sample determinations are necessary for equitable adjustment of payment on account of excessive moisture in coal which is stocked in piles exposed to the weather.

The specifications provide for the collection of "special moisture samples" if, in the opinion of the Government officials sampling it, the delivery contains moisture in excess of that guaranteed by the contractor. The "special moisture samples" are prepared in a manner to minimize moisture losses and may be taken and prepared independently of the gross samples collected for the determinations of heating value (B. t. u.), ash, and other specified data. If the analysis of the special sample shows a moisture content in excess of the contractor's guaranty, a proportionate deduction is made from the price to be paid for the coal.

"Special moisture samples" representing coal as delivered should be preserved in such a way as to minimize moisture loss, because if the moisture content of the sample, as shown by analysis, is less than the actual moisture content of the coal at the time it is weighed, either because of the sample being nonrepresentative or because of subsequent moisture loss during the storage or the preparation of the sample, the price to be paid for the coal delivered is correspondingly increased and an injustice is done the purchaser. It is equally important to protect the sample during collection or storage from becoming wet by rain, snow, or water from any other source, in order to insure that the sample represents the delivered coal. Evidently, therefore, particular attention should be given to procuring for the laboratory a sample containing the same percentage of moisture as the delivered coal.

To minimize moisture loss, the sample must be placed in a tight container and stored in a cool place before it is reduced. Moreover the sample should be reduced and transmitted to the laboratory as soon as practicable. It is well to remember that a sample taken from coal that has been exposed to a relatively high temperature, as coal from a boiler or furnace room, or from adjacent bins, has lost moisture and does not represent the coal as delivered. For the same reason the samples should not be stored in a boiler room.

If the contractor does not guarantee a moisure content lower than can be actually maintained on an average, the collection of "special moisture samples" and the making of price corrections on account of excessive moisture will seldom be necessary. Thus, the placing of heating value (B. t. u.) on the "dry coal" basis, with a maximum moisture content, eliminates frequent corrections of price on account of uncertain moisture variations.

ASH AND HEATING VALUE.

The heating value of coal from the same mine or from a group of mines operating the same bed of uniform character is directly influenced by the percentage of ash. By ash is meant earthy matter and impurities that do not burn. As the proportion of ash inherent (sometimes termed "intrinsic ash") in the coal substance as a rule does not vary widely in coal from the same bed, the heating value is largely determined by the amount and character of the free (sometimes termed "extraneous") impurities, and hence the manner in which coal is cleaned and prepared at the mine may greatly affect the heating value of commercial shipments. In collecting samples, therefore, it is of utmost importance that the samples should contain within reasonable limits the same proportion of impurities as the delivered coal from which they were taken.

As the specifications provide for adjustment of price according to the ash content or the heating value, or both, it is evident that samples taken from delivered coal should show, by analysis, practically the same ash content and heating value as the delivered coal. In other words, the sample should contain the same proportion of slate, bony coal, pyrite and other impurities as the quantity delivered, in order that the price adjustment based on the analysis may be fair to both purchaser and seller. Obviously, it is important to guard against any accidental admixture of sand, cement, clinkers, or other foreign matter while the sample is in storage or while it is being prepared for transmittal.

In this connection, attention is called to the fact that the gross sample should contain the same proportion of lump and fine coal as the delivered coal, for it has been determined that fine or slack coal may have an ash content, or a heating value, different from lump coal from the same shipment.

VOLATILE MATTER.

The volatile matter[a] of coal, as shown in analyses, generally contains some inert noncombustible matter, the proportion of which may range from 1 to 15 per cent. The character of the volatile matter in any given coal and the temperatures at which it is given off bear directly on the design and operation of furnaces for burning the coal efficiently and without smoke. The proportion of combustible and noncombustible constituents in the volatile matter and the character of the combustible constituents differ in different coals, and, therefore, the heating value of a coal can not be determined from a proximate analysis. Moreover, different coals with the same proportion of volatile matter may not behave alike in the furnace.

[a] Porter, H. C., and Ovitz, F. K., The volatile matter of coal: Bull. 1, Bureau of Mines, 1910, 56 pp.

In order to determine the comparative value of two coals for the same purpose, it is important to know both their chemical composition and their heating value. Hence the specifications recommended by the Bureau of Mines provide that before final awards of contracts, practical service tests may be made to determine the relative suitability of the coals offered.

In the specifications the contractor is required, in addition to giving the name and the location of the mine or mines producing the coal and the name of the coal bed worked, to specify the volatile matter content and other proximate analysis determinations of the coal he proposes to furnish. The volatile matter content he specifies becomes the standard of his contract, and delivery of coal with a different percentage of volatile matter, indicating the substitution of a coal other than that offered, may result in the coal being rejected and the Government purchasing coal in the open market (the contractor being charged with the difference, if any, in cost) or in the contract being canceled.

The Government does not consider any scheme of applying penalties on account of variations in volatile matter equitable, because the character of the volatile matter and its heating value are not necessarily indicated by the volatile matter determination, and because this determination is made by an empirical method whereby duplicate determinations on the same sample may differ as much as 2 per cent in different laboratories, or, in fact, in the same laboratory. Accordingly, no corrections in price are made for variations in volatile matter.

The bureau has received copies of commercial and municipal specifications drawn up apparently without regard to these facts. One specification, for instance, provides for a correction of 2 per cent in price for each 1 per cent of volatile matter in excess of the standard guaranteed. On a coal sold at $3 per ton a deduction of 12 cents per ton might be made for an apparent excess of 2 per cent in volatile matter, when, in fact, the actual volatile matter of the coal was not above the standard. Specifications of this nature furnish legitimate grounds for opposition from coal companies and do much to discredit the specification method for the purchase of coal.

SULPHUR AND CLINKER.

Sulphur is commonly present in coal in combination with iron or other elements. For a long time it was thought that the sulphur formed clinker, but recent investigations point to the fact that sulphur is not the only cause of clinkering; in fact, there may be no difficulty from clinker in burning coal containing as much as 5 per cent or more sulphur. The relative proportions of iron, sulphur, lime, alumina, silica, etc., in the ash affect its fusibility, whereas the method of

firing and the rate of combustion are important factors in the formation of clinkers. The exact relation of clinkering to the constituents of the ash is not known so well that one can definitely predict from an analysis of the ash whether a coal will or will not clinker. At many power plants the fireman slices the fire too often and works the ash up from the grates into the hot coal bed, where it melts and fuses into heavy, dense masses of clinker. At high rates of combustion the ash in a given coal may clinker (though at lower rates it does not) because of the ash being raised to the fusing temperature. The fact that the percentage of sulphur does not necessarily indicate the behavior of the coal in the furnace is recognized in the specifications recommended by the Bureau of Mines. The contractors, however, are required to specify the sulphur content so that standards for the coals to be delivered may be established.

Many commercial and municipal specifications exact penalties for a slight increase in the sulphur content, although coal of high sulphur content may clinker less and its heating value may be higher. One specification received by the Bureau of Mines exacts a deduction of 5 per cent in price for each 1 per cent of sulphur in excess of the standard. In the case of a coal supplied at $3 a ton, the presence of 1 per cent of sulphur in excess of the standard, as indicated by analysis, would often result in an unwarranted deduction of 15 cents a ton. Under such a contract, the variations which it is recognized exist in sampling and analysis may cause a contractor unjustly to suffer a heavy deduction.

Both the sulphur and the volatile-matter content should be used to classify coals and to identify the coal guaranteed. Variations indicating the substitution of an unsatisfactory coal should be considered cause for rejection of the coal or for cancellation of the contract.

NEED OF EXPERIENCE AND CAUTION IN SAMPLING.

Persons without experience generally select a sample better than the average run of the coal delivered. Occasionally, a lump unusually free from layers of slate and impurities, and representing the best coal in the lot rather than the average, is selected. After being broken it is shipped to the laboratory in a cloth sack, so that it loses moisture during transit. The analysis of such a sample necessarily indicates a value higher than that of the coal delivered. As a quantity of coal may vary greatly in composition, containing not only what may be termed coal proper with certain more or less constant impurities, but also slate, pyrite, and bony coal, a lump may be anything from almost pure coal to material without fuel value. Hence the analysis and test of a single lump may indicate a composition greatly different from that of the coal at hand. It is well to remember that, as the

larger lumps of coal roll down and collect near the bottom of a pile or load, a sample taken entirely from near the floor does not always fairly represent the whole.

In spite of every precaution taken to prevent loss of moisture during the collection, preparation, and analysis of samples, it is certain that loss of moisture may occur; also there may be too little or too much slate, bony coal, or other foreign matter collected in what is otherwise a truly representative gross sample, so that the determination of the heating value or ash content does not strictly agree with the actual value of these factors in the coal delivered. However, an experienced collector, by using good judgment and following the general directions given for collecting and preparing samples, can obtain samples so fairly representative that the results of the analyses are reasonably accurate. The suggestions that follow are presented for the guidance of those who wish to send representative samples to a laboratory for analysis and heating-value tests.

DIRECTIONS FOR SAMPLING.

SIZE OF THE GROSS SAMPLE.

The number of pounds to be taken as a gross sample to represent a given lot of coal varies with the character and condition of the coal, and not with the amount of coal to be sampled. The character and proportion of the bony coal, slate, etc., and the size of the particles of both coal and impurities are the governing factors. It is therefore evident that sampling should not be left to an inexperienced person, but should be done by one who is thoroughly familiar with the significance of these factors and has some knowledge of the coal to be sampled.

There is greater probability of taking too little than of taking too much coal for a gross sample. It is generally true that the larger the gross sample the less is the chance of its being nonrepresentative. Large samples must be taken in sampling coals that carry a varying proportion of large pieces of slate, bony coal, or pyrite, for it is evident that including or excluding large pieces of the impurities must affect the analysis of a small sample considerably; hence, the analysis may not indicate the quality of the coal sampled and, consequently, may be worthless for determining the price to be paid for the coal. If the free impurities are small particles and are well distributed throughout the coal, representative samples may be obtained easily.

Bailey[a] has contributed valuable information to the study of sampling coal. He gives the results of experiments and studies made to determine the size of samples and methods of sampling required

[a] Bailey, E. G., Accuracy in sampling coal. Paper read before industrial division of American Chemical Society, Baltimore, Dec. 31, 1908. How to sample coal and coke, Fuel Testing Co., Bull. 4, 1910.

for reliable analyses. The "size-weight" ratio or percentage, that is, the ratio of the percentage of the largest pieces of slate to the total weight of the sample, is shown, and appears to be the most important factor for consideration in the sampling of coal. The fundamental principles as stated by Bailey were recognized in the experiments and investigations conducted by the Bureau of Mines. The conclusions reached by the bureau as to the size of samples to be collected, and the sizes to which a sample should be crushed at its various stages of reduction in quantity, substantiate the results of Bailey's work.

As a result of these experiments and tests it has been found that as the size of the sample is decreased the differences between separate samplings become greater and greater. In the case of very small samples[a] the difference may become equivalent to that between pure coal and slate. On the other hand, it has been found that as the weight of the sample is increased, the difference rapidly decreases, until a point is reached where the accuracy obtained by taking larger samples is affected but slightly. This would not ordinarily be warranted, because of the expense which would be involved in making special provisions for handling the very large samples.

The large differences obtained with small samples show very forcibly the necessity for collecting large gross samples in order to insure the results of analyses and reliable heating-value tests, from which the proper price to be paid for delivered coal can be determined and injustice to either seller or buyer prevented.

As a result of the tests it has been established that a gross sample of approximately 1,000 pounds is sufficient to give reliable results for coals comparatively easy to sample; that is, coals relatively free from the "extraneous" impurities. It may be necessary to collect larger gross samples, even 1,500 pounds or more, for coals containing a considerable proportion of impurities in large pieces, or large lumps of coal with streaks of bone, slate, or pyrite, or sulphur balls and lenses.

Whether a delivery consists of 1 ton, 500 tons, or more, the need of the gross sample weighing 1,000 pounds or more is the same. One such sample carefully taken and reduced to a quantity convenient for transmittal to the laboratory can well represent a delivery of several hundred tons, a thousand tons, or more.

For convenience, however, and to avoid long storage of the samples, the Bureau of Mines considers it advisable that one sample of 1,000 pounds, or more, should be collected weekly in the case of Government contracts calling for more or less regular deliveries each week. If, however, the quantity delivered during a week is relatively small, then the sample may represent the coal delivered during

[a] In this bulletin the word slate is used as a commercial, not a geological, term and signifies shale.

a longer period. To facilitate accounting, many branches of the Government service order contractors to deliver in certain quantities, usually 100 to 500 tons. In such cases the samples are collected to represent the order without special regard to the period covered, and one or more gross samples of 1,000 pounds or more each are collected, as may be most practical and expedient in view of the facilities for sampling and the other considerations involved.

In sampling cargo deliveries of 5,000 and more tons, the Bureau of Mines collects from 3,000 to 4,000 pounds of coal as a gross sample. In order that the preparation of the samples may proceed while the cargo is being loaded, after approximately 500 pounds has been collected it is reduced to a quantity convenient for mailing to the laboratory, and each succeeding 500 pounds is likewise reduced. This procedure makes unnecessary the accumulation of a quantity of coal that can not be systematically and conveniently handled in the short time and the small space usually available. Two or more of the samples are combined and reduced to one in the laboratory, and four or five analyses are usually made for a cargo, and a report on the cargo is obtained by averaging the analyses. The samples may, however, be mixed in the laboratory and only one analysis made to represent the cargo. Though the experiments which have been made indicate that a sample of approximately 1,000 pounds will give results fairly representative of the cargo, the objection to the 1,000-pound sample is that it is too small to allow of the frequent collection of shovelfuls or portions of any quantity throughout the loading of a large cargo. As it generally happens that coal from a number of mines is loaded into the same cargo, it is desirable to collect a considerable quantity of coal, so that each mine may be well represented in the gross sample. It is obvious that the more frequently the portions are collected and the greater the quantity sampled, the less the probability that the sample will be nonrepresentative; accordingly, the bureau considers that in sampling 5,000-ton cargoes safety lies rather in the larger gross sample.

WHEN TO COLLECT SAMPLES.

The best opportunities for procuring representative samples are afforded while the coal is being loaded into or unloaded from railroad cars, ships, and barges, or while it is being dumped from wagons. Once the coal is stored in piles or bins, or loaded on cars or vessels, the procuring of representative samples is practically impossible unless the whole quantity of coal is immediately handled again and the conditions for sampling become favorable. Samples collected from the coal exposed in piles, bins, barges, cars, or ships can be considered representative only under the condition that the mass of coal is homogeneous throughout. Such a condition is highly

improbable and uncertain, and the analysis of samples collected from the surface may give results that are very unreliable as indicating the nature of the entire quantity, and that may be worthless as a basis for determining an equitable price to be paid for the coal.

COLLECTION OF GROSS SAMPLES.

When coal is being loaded into or unloaded from wagons, railroad cars, ships, or barges, a shovel or a specially designed tool may be used for taking portions or increments of 10 to 30 pounds to make up the gross sample of coal. As the size of the increments should be governed by the size and weight of the largest pieces of coal and impurities, increments of more than 30 pounds may be required for coals containing large pieces of coal and impurities.

If one chute or conveyor is used for delivering a considerable quantity of coal to or from wagons, cars, or ships, it may prove expeditious and economical to devise a mechanical means for collecting portions from fractional parts of the discharged coal, or continuously deflecting a portion of the coal as it falls down the chute, or diverting from the conveyor definite portions of coal, and thus mechanically and automatically collecting the gross sample.

The mechanical collection of samples is preferred to shovel sampling, as it eliminates the personal equation. The mechanical sampler does not discriminate for or against taking more or less slate or other impurities. A person should collect samples with a shovel in the main without regard to impurities, leaving the amount of the impurities included in a sample largely to chance, as it is impossible to rate correctly the proportion of the impurities concealed in the coal, however competent the sampler may be. A mechanical sampler should preferably take the whole of the stream of coal flowing down the chute a part of the time rather than a part of the stream all the time, because the sizes and character of the pieces of coal and impurities are not apt to be evenly distributed across the stream. Excellent opportunity is afforded for procuring representative samples if the entire consignment of coal is crushed immediately after it is weighed and delivered, for then the samples can be collected from the crushed coal. If the coal is conveyed from the crusher by a conveyor, means can be devised for mechanically and automatically diverting from the conveyor definite portions of coal to make up the gross sample.

The portions should be regularly and systematically collected, so that the entire quantity sampled will be represented proportionately in the gross sample. The interval at which the portions are collected should be regulated so that the gross sample collected will weigh not less than approximately 1,000 pounds. If the coal contains an

unusual proportion of impurities, such as slate, bony coal, and pyrite, and if the pieces of such impurities are very large, it will be necessary to collect gross samples of even 1,500 pounds, or more, but for slack coal and for small sizes of anthracite, if the impurities are not in abnormal proportion or in pieces larger than about three-quarters of an inch, and are evenly distributed throughout the coal, a gross sample of approximately 600 pounds may prove sufficient. The gross sample should contain the same proportion of lump coal, fine coal, and impurities as the coal delivered. As soon as the portions are collected they should be deposited in a receptacle having a tight-fitting lid provided with a lock.

WAGONLOAD SAMPLING.

A gross sample taken by hand from coal delivered by wagon at a Government building should consist of shovelfuls of coal taken from the first, second, or third wagonload as it is being discharged, the number of shovelfuls taken and the loads sampled being dependent on the number of loads which the gross sample is to represent. If the coal is discharged immediately into a crusher, it is preferable to collect shovelfuls of the crushed coal.

If it is desired to sample coal delivered in small lots by wagons to a large number of buildings from one source of supply where the coal is all weighed, and if the collection of samples at each building will involve considerable expense, samples may be conveniently collected at minimum expense at the source of supply when the coal is loaded into the wagons. In such case the samples are collected without regard to delivery points, the object being to sample the coal loaded into the wagons. At the end of the month or upon the completion of an order the corrected price per ton, if there be any corrections on account of coal varying from the standards guaranteed by the contractor, applies to each individual delivery point. Shovelfuls of coal should be taken from each wagonload, or every second or third, etc., wagonload, the number of shovelfuls taken and the number of wagonloads sampled being dependent upon the number of loads which the gross sample is to represent.

It is important to obtain representative portions of coal from every part of the delivery, so that the sample will show the quality of the delivery or order as a whole. The gross sample should contain about the same proportion of lump coal, fine coal, and foreign matter as the coal delivered.

CARLOAD SAMPLING.

Samples taken from railroad cars should not be limited to a few shovelfuls of coal procured from the top of a car, for the size of the coal and the proportion of foreign matter may vary from the top to

the bottom of the car. The only way to obtain a representative sample is to take a number of shovelfuls or portions of coal from different points in a car, from top to bottom and from end to end, while the coal is being loaded or unloaded.

When a shipment of coal is sampled at the mine, shovelfuls or portions of coal should be taken systematically as the coal is loaded into the railroad car, and with such regularity that the sample will represent the entire carload. The frequency of collecting the portions will depend on the number of cars of coal to be represented by one gross sample. If only one carload is to be sampled, a gross sample of 1,000 pounds, or more, should be collected. If two or more cars of coal are to be represented by the sample, proportionate amounts to make up the gross sample should be taken from the coal as it is loaded into each car. The samples should be taken after the coal has been prepared for market; that is, if the coal is passed over picking tables or pickers are employed on the car to remove the impurities from the coal, the samples should be taken only after the coal has had its final preparation.

When sampling coal delivered from open cars and unloaded by hand shovelfuls should be taken at regular intervals as the coal is unloaded into wagons or bins.

When coal is being sampled from dump cars, ladlefuls (see p. 19) or shovelfuls should be taken from the stream of coal being discharged to the bins or ship. If the discharged coal is immediately crushed the gross sample should preferably be collected after the coal leaves the crusher.

If a number of carloads are delivered on an order or during a short period the preparation of a gross sample of 1,000 pounds or more for each car would involve considerable time, labor, and expense at the delivery point, as well as in the laboratory; in fact, a gross sample for each car would not be required, for if a gross sample is carefully taken and prepared it can well represent a number of cars. If a gross sample is collected to represent two or more cars representative portions of the coal should be taken in equal quantities from each car.

The method followed by the Bureau of Mines in sampling coal discharged from railroad cars directly into ships is given under "Cargo sampling."

CARGO SAMPLING.

In sampling cargoes, as in sampling carloads, portions of coal should be taken in equal quantities and at frequent and regular intervals so as to represent proportionate parts of the consignment as a whole, either while the coal is being loaded or unloaded. There is no assurance that a sample or a series of samples taken from the top of the cargo represents the cargo as a whole; in fact, it is very doubtful if such samples are ever representative.

The Bureau of Mines has charge of the sampling of cargo shipments of coal to the Isthmus of Panama for the Panama Rail Road Co. The coal, which is loaded from piers at Hampton Roads, Norfolk, and Newport News, Va., is dumped directly from railroad cars into ships carrying from 4,000 to 12,000 tons of coal. The method followed is to collect portions of coal from every railroad car dumped. From 30 to 60 pounds are taken from each car sampled, the quantity taken depending on the size of the cargo. From 3,000 to 4,000 pounds are usually collected as a gross sample to represent a cargo (see p. 15 under "Size of the gross sample"). The gross samples are reduced in successive stages as collected, rather than accumulated and later reduced to quantities convenient for transmittal to the laboratory.

The portions making up the gross samples are taken from the coal as it is discharged from the bottom-dump cars by the use of a shovel or a specially constructed ladle. The ladle has a handle about 5 feet long and a bowl 1 foot in diameter at the top, 9 inches at the bottom, with depth of 9½ inches, and holds from 25 to 30 pounds of coal. To collect samples with the ladle, it is rested on the rails of the track or on the chains that support the gates of the car. Two ladlefuls are usually taken from a car, one from one side and the other from the other side at the opposite end, thereby obtaining portions from different parts of the car. Care is observed to not collect portions of the first or last coal spilling from the car, for the moisture content or proportions of foreign matter in such coal may render the sample unrepresentative. If circumstances permit, the ladle is shifted and filled from different sections of the stream of falling coal. It sometimes happens that the coal is discharged very rapidly, in which case the collector must be alert to collect portions at the most desirable periods and must take care that the coal does not wrench the ladle out of his hands or jerk him down and do him bodily injury.

The method of sampling cargo shipments has been established as the result of numerous experiments, and it has been determined that the analytical reports obtained are representative within limits reasonably to be expected for work of this nature.

The bureau is making a study of the conditions on the piers, with a view of devising means whereby the samples can be automatically and mechanically collected, prepared, and reduced to quantities convenient for transmittal to the laboratory. At one of the three railroad terminals loading at Hampton Roads, Va., the bureau has installed a crusher for crushing the gross samples to $\frac{3}{16}$-inch mesh and finer, and parting devices for reducing the samples in quantity, thereby eliminating the hand preparation of samples. It is proposed to install crushers and equipment at the other two points.

Because of the suddenness with which the coal may break through and drop out of the railroad car after the gates are open and because of the momentum of the rapidly falling coal, it may be impossible to collect a satisfactory sample by attempting to catch coal in a shovel or ladle. In such event, it may be necessary to collect shovelfuls of the coal that has overflowed on the pier. If beams 10 to 12 inches wide span the pockets immediately underneath the car, a fairly satisfactory sample can often be collected in shovelfuls from the coal lodging on the beams.

Though the collector may use the shovel or ladle to the best of his ability, these tools may collect portions of coal that do not contain lump coal in the same proportion that exists in the car. Especially may this occur if the coal contains a large proportion of lumps of considerable size. In that event, the collector should collect portions of lumps from time to time and add them to the sample. Necessarily the collector must be relied upon to collect a sample under these conditions that will fairly represent the proportions of lump and slack coal contained in the coal sampled, and it follows that the collector must have experience in sampling and be able to judge the coal and the sample.

In sampling large quantities of coal in a short period, the collector frequently works under disadvantages and has not the opportunity to select more leisurely and methodically portions of coal to make up a gross sample, as he can in sampling wagonload deliveries or in single carloads or barges unloaded by shovel, clam shells, or grab buckets, and this fact should be considered in comparing the results of sampling cargo with wagon or railroad-car deliveries.

In collecting samples from coal as it is unloaded from a ship, the same general instructions apply; the cargo being systematically sampled during the entire period of unloading, so that samples will be collected which represent the quantity as a whole. If unloaded by grab buckets or into barrows, shovelfuls should be collected at regular intervals from the buckets or barrows. If the coal is crushed immediately after it is unloaded, it is preferable to collect samples from the crushed coal.

SAMPLE RECEPTACLE.

As the wagons or railroad cars may arrive irregularly at the building or plant and the coal be intermittently unloaded, a metal receptacle or wooden box of a size to hold a gross sample of at least 1,000 pounds, with a tight-fitting lid which can be locked, is required for holding the portions of coal taken from each wagon or car until the gross sample is completed. In sampling cargo deliveries, buckets holding 60 to 70 pounds may prove more satisfactory to use for receiving the portions making up a gross sample, as the samples are

usually worked down as the loading progresses and the buckets are convenient for carrying the coal to the space available for preparing the gross samples. If the gross samples are stored, a box should be provided or else a sufficient number of buckets with tight-fitting lids and locks should be available in order to preserve the integrity of the sample.

The buckets, boxes, or receptacles should be inspected each time before using and thoroughly cleaned to remove the coal dust remaining from previous samples and any foreign matter that may by chance be in them.

COLLECTION OF SPECIAL MOISTURE SAMPLES.

During the collection of gross samples and their reduction to quantities that are convenient for transmittal to the laboratory and that correctly represent the ash, sulphur, and heating value of the coal sampled, it is ordinarily impossible to retain in the sample all the moisture that was in the delivered coal. Obviously, if it is desired to determine the amount of moisture in delivered coal, special moisture samples are usually necessary. Owing to the fact that a sample unavoidably loses moisture during every stage of handling and preparation, the special moisture samples must be, in a sense, grab samples and must be collected, prepared, and placed in a sealed container with as little delay as possible.

If a gross sample is collected during a period of a few hours or a very few days and the sample is collected and stored under conditions that will preserve its moisture content, a special moisture sample may be collected from the gross sample after it has been rapidly crushed, so that it will all pass through a 1-inch screen (the fineness to which the gross sample is reduced by the first crushing, see table on p. 25). It should be collected in a place comparatively cool and protected from rain, snow, wind, and the sun's rays. A small scoop may be used for collecting the sample. The scoop should have a capacity of about one pound of coal—a scoop with bottom about 2½ inches wide and 8½ inches long and vertical sides about 2 inches high is about the right size. As the crushed coal is shoveled into a conical pile (p. 26), scoopfuls should be regularly and systematically collected so that approximately one scoopful will be collected to every two shovelfuls (about 30 pounds) deposited on the cone, thereby collecting a special moisture sample weighing from 30 to 50 pounds. As the scoopfuls are collected they should be placed in a receptacle which can be tightly closed. After the gross sample has been formed into a conical pile (p. 26) and the special moisture sample weighing 30 to 50 pounds has been accumulated, the special moisture sample should be immediately and rapidly crushed so that no pieces

of coal or impurities are larger than one-half inch; and it should be rapidly coned, flattened, and quartered, and a mailing can (p. 32) filled by taking portions from each quarter by use of the scoop (each portion only partly filling the scoop). The mailing can should be properly sealed at once (p. 36) and forwarded to the laboratory.

If the gross sample in the above case is crushed mechanically and reduced to the quantity desired for transmittal to the laboratory by use of sampling machines in such a manner and in machines so designed that moisture losses are minimized, then the collection of a special moisture sample may prove unnecessary, as the moisture determination made on the regular sample will represent, within reasonable limits, the moisture content in the coal delivered.

If a gross sample is collected during a period of several days, and if it is manifest that the sample will lose moisture during its storage and preparation, the special moisture sample should be accumulated by placing in a receptacle small portions of the freshly taken increments making up the gross sample. Under these conditions it is desirable that a receptacle which can be hermetically sealed and has a capacity of about 100 pounds be provided in which to preserve the portions making up the special moisture sample as they are taken each day. After the gross sample is accumulated a quantity convenient for transmittal to the laboratory should be selected from the special moisture sample (in accordance with the method given above) and forwarded in the mailing can, properly sealed for special moisture determination.

If two or more railroad cars are to be represented by one gross sample, and if the cars contain different amounts of moisture seemingly in excess of the maximum moisture content guaranteed, moisture samples should be taken separately from each car. If a single gross sample is to represent several days' delivery, and if because of heavy intermittent rains there is a considerable difference in moisture content between each day's delivery, and each contains moisture in excess of the maximum content guaranteed, then a special moisture sample should be taken representing each day's delivery. Payment for the entire quantity on account of ash and B. t. u., "dry coal," is determined from the analysis of the gross sample, but corrections on account of excessive moisture should apply to the particular car or cars, or day's delivery. The purchaser would be at a disadvantage on account of heavy rain if corrections for moisture did not apply to each day's delivery or fraction of the delivery, because if the special moisture samples were mixed, and one special moisture determination only made, the effect of the heavy rains would largely be averaged out in the mixture, and, in addition, in storing, mixing, and reducing the samples there would be more or less moisture lost.

PREPARATION OF THE GROSS SAMPLE.

Though a gross sample may be collected ever so carefully and may represent the coal sampled, unless it is prepared in accordance with well recognized principles, the results of analysis and test may be worthless for determining equitable settlement for the coal.

The portions taken in making up the gross sample should be immediately placed in a box or a receptacle having a tight-fitting cover and a lock, for storage in order to preserve its integrity until it is reduced to a quantity convenient for transmitting to the laboratory.

If it is desired to determine the moisture content of a gross sample that has been collected in a comparatively short time under precautions to minimize moisture loss, the sample should be placed in a comparatively cool place and the crushing, mixing, and reduction for shipment to the laboratory should be done as rapidly as possible; this is imperative if the analysis of the sample is to represent the approximate condition of the coal with respect to its moisture content at the time it was weighed. Obviously, a sample on which a moisture determination is desired should be protected from rain and snow and strong air currents or winds and the sun's rays during its storage and preparation.

The proper preparation of a gross sample for shipment to the laboratory involves three operations: (1) Crushing, (2) mixing, and (3) reduction in quantity. The operations proceed in stages until the final sample is obtained.

The crushing may be done by a mechanical crusher or by hand with an iron tamping bar or sledge on a smooth, clean, sheet-iron plate, of suitable dimensions, or on a solid floor—in the absence of a sheet-iron plate or smooth, tight floor, the crushing may be done on a heavy canvas—to prevent the accidental admixture of any foreign matter. The mixing and reduction may be done by hand with a shovel, or mechanically by means of riffles or sampling machines.

It is obvious that if the gross sample is reduced in quantity without crushing, the effect of the selection or rejection of one or more of the large pieces of slate or other impurities in the portion of the sample retained multiplies rapidly as the sample becomes smaller. To illustrate: A sample of 1,000 pounds contains a piece of slate weighing 1 pound, which is one-tenth per cent of the weight of the gross sample. If the sample is halved in quantity without crushing, the half of the sample retained for further reduction will contain two-tenths per cent ash more or less than the rejected half, according to whether the piece of slate went into the retained half or into the rejected half. In halving the 500-pound sample, the 1-pound piece of slate would have an effect of four-tenths per cent on the ash content of either the retained or rejected half. If, in continuing the reduction of the sample

by halving each time, the 1-pound piece of slate by chance should fall into the retained half on each successive halving, it would have an effect of 12.8 per cent on a $7\frac{1}{16}$-pound sample—that is, in halving the $15\frac{5}{8}$-pound sample the 1-pound piece of slate would cause the ash content of one-half of the sample to be 12.8 per cent higher than the other; in other words, if the average ash of the coal is 10 per cent, one of the $7\frac{1}{16}$-pound samples would show an ash content of 22.8 per cent. This fundamental principle that the weight of the largest piece of impurities should be relatively very small in ratio to the weight of the sample at each halving is recognized in the instructions for sampling issued by the Bureau of Mines, which specify that the sample should be successively crushed, mixed, and reduced.

In the sampling of ores it is recognized that the particles of ore must be crushed to varying degrees of fineness in order to obtain results within an allowable limit of error, and to accomplish this, elaborate and costly plants are constructed and maintained. Brunton [a] states that experiments and calculations and a general consideration of the subject indicate that the size to which ore must be crushed for sampling in order to reduce error within an allowable limit will depend on:

1. The weight or bulk which the sample is to have. Evidently the smaller the sample the finer the material must be crushed.

2. The relative proportion between the value of the richest mineral and the average value of the ore. If the average grade of the ore is high in comparison with the grade of the richest mineral, a particle of richest mineral of a given size and value will have less percentage effect on the sample than the same particle would have on the same amount of lower-grade ore; therefore, other conditions being the same, with high-grade ores we may crush more coarsely than with low-grade ores and still keep within the same percentage of error; while if the richest mineral is of comparatively high grade a particle of it of given size will have a greater effect on the sample than if it is of low grade, and this will necessitate finer crushing.

3. The specific gravity of the richest mineral. The higher the specific gravity of the richest mineral the greater the value contained in a particle of given size and grade, and hence the greater the influence of such particle on the sample; from which follows the necessity of keeping down the size of the largest particles by finer crushing than is required when the richest mineral is of lower specific gravity.

4. The number of particles of richest mineral which are likely to be in excess or deficit in the sample is evidently an important factor, a liability to a large number necessitating especially fine crushing. But such liability can result only from imperfect mixing, and for material mixed with average thoroughness this number must be small.

And in conclusion this paper further states that:

The results of the investigations recorded in this paper show how absolutely necessary it is that ore samples should be recrushed after each successive "cutting down," so that as the sample diminishes in weight there may be a nearly constant ratio between the weight of the sample and that of the largest particle of ore contained therein.

[a] Brunton, D. W., The theory and practice of ore-sampling, Trans. Am. Inst. Min. Eng., 1895, vol. 25, p. 827.

In applying these principles to coal, slate and other impurities are to be considered as taking the place of the "richest mineral," but, as coal is a low-priced commodity, the cost of collecting and preparing samples must necessarily be correspondingly small, making the installation and operation of elaborate sampling plants prohibitive.

Though the fineness to which the Bureau of Mines specifies that samples be crushed may not be strictly in accordance with the fineness that would be necessary for theoretically accurate reduction of the samples, and as coal of a definite physical character and composition would require special treatment, the fineness specified in the table below, it is believed, will give results that are fairly representative.

When prepared by hand the pieces of coal and impurities should be crushed to sizes not greater in any dimension than the sizes indicated in the following table before each reduction of the sample into two approximately equal parts:

Size of coal and quantity required for each reduction.

Largest size of coal and impurities allowable in sample before division.	*Weight of sample to be divided, pounds.*
One inch	1,000 or more.
Three-quarters of an inch	500
One-half inch	250
Three-eighths of an inch	125
One-quarter of an inch	60
Three-sixteenths of an inch, or 4-mesh screen	30

Diagram showing the treatment of a 1,000-pound sample.

1,000-pound gross sample, crush to 1-inch mesh; mix by coning and long-pile method; halve by alternate shovel method.

Rejected portions.

- 500 ↓ — 500 pounds, crush to ¾-inch mesh; mix by coning and long-pile method; halve by alternate shovel method.
- 250 ↓ — 250 pounds, crush to ½-inch mesh; mix by coning method; halve by quartering method.
- 125 ↓ — 125 pounds, crush to ⅜-inch mesh; mix by rolling on blanket; halve by quartering method.
- 62½ ↓ — 62½ pounds, crush to ¼-inch mesh; mix and halve by blanket and quartering method.
- 31¼ ↓ — 31¼ pounds, crush to $\frac{3}{16}$-inch or 4-mesh; mix and halve by blanket and quartering method.
- 15⅝ ↓ — 15⅝ pounds; mix and halve by blanket and quartering method.

→ 7 13/16 pounds. Fill 5-pound container and mail to laboratory.

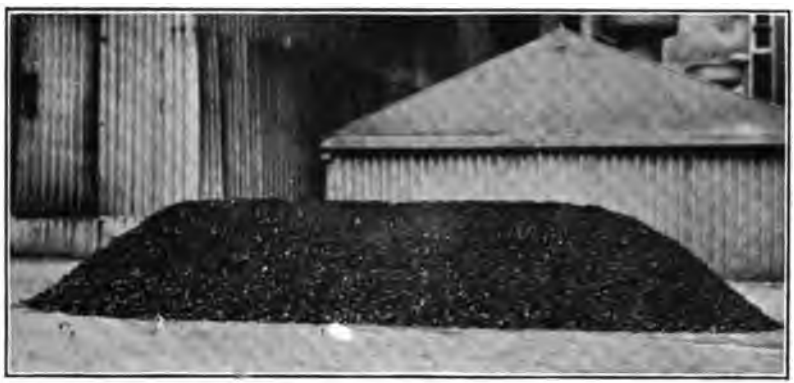
7 13/16 pounds. Fill 5-pound container for reserve sample.

Care should be exercised to crush finely pieces of foreign matter before each reduction so that the crushed impurities can be distributed through the sample, and when crushing to keep pieces of slate and other impurities from flying out of the sample. In crushing the coal on wood, brick, cement, or on floors of such materials, splinters or small fragments may be broken from the floor and be mixed with the sample. Such floors, if used, should be thoroughly clean and free from cracks. If a sheet-iron plate is used, it should be free from rust.

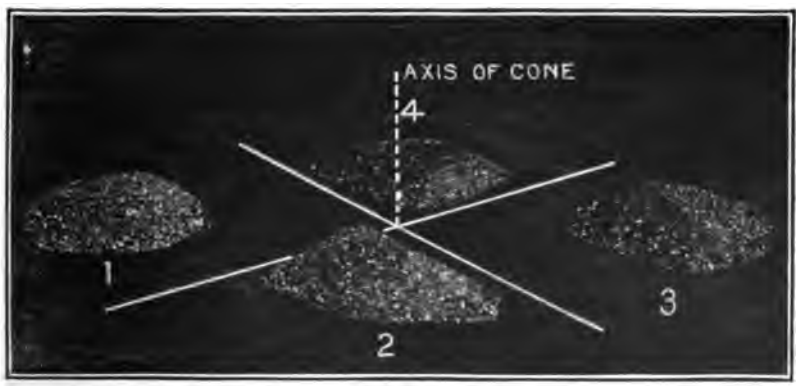
After each crushing the sample should be thoroughly mixed before reduction in quantity. The method which gives generally satisfactory results is as follows:

The crushed coal is formed into a conical pile by depositing each shovelful of coal on top of the preceding one (see Pl. I, *A*, which shows approximately 1,100 pounds of coal crushed to 1-inch mesh and finer, properly coned.) As the shovelfuls are deposited the fine material forms the apex of the cone, while the coarse particles roll down toward the base. By walking around the cone and systematically depositing shovelfuls on the apex of the cone from every side, care being taken to maintain the original form, the sampler will properly distribute the fine and coarse coal. A new, long pile is then formed by taking a shovelful at a time (as the sampler fills the shovel he should walk around the cone, thus systematically removing the coal from the base of the cone) and spreading it out in a straight line or ribbon the width of the shovel; the length is 5 to 10 feet for a shovel holding about 15 pounds. Each new shovelful is spread over the top of the preceding one, beginning at opposite ends, and so on until all the coal has been formed into one long pile. (Pl. I, *B*, shows the coal of the cone formed into a long pile.) The sample is then halved in quantity by shoveling the long pile to one side, alternate shovelfuls being discarded while the retained shovelfuls are formed into a new cone. In shoveling the coal from the long pile the sampler takes the shovelfuls of coal systematically around the pile, advancing at each shovelful a distance about equal to the width of the shovel, thereby preserving the symmetry of the form of the pile. If the pile should be reduced by shoveling all of the coal from either end, and if the alternate shovelfuls discarded contained coal mainly from the sides of the pile, the rejected half of the sample would contain a preponderance of coarse coal, while the retained half would contain relatively too much fine coal. This is because the coarse coal rolls down the sides of a pile or cone while the fine coal builds up, so that the relative proportions of coarse and fine coal in outer and inner portions of the pile are quite different. The alternate shovelfuls of coal which are retained are formed into a new cone.

A. CRUSHED GROSS SAMPLE IN CONICAL PILE.



B. CRUSHED GROSS SAMPLE REMIXED IN LONG PILE.



C. REDUCED SAMPLE QUARTERED.

In coning, care should be observed to deposit each shovelful so that the center of the cone as started will not be drawn to one side, for in quartering a cone the center of which has been drawn, two opposite quarters will contain an excess ratio of fine material, while the other two quarters will contain a deficiency. This will be apparent when it is considered that when a cone is formed, the fines build up the apex while the coarse particles roll down the sides. In ore sampling this may be of especial importance, as the fines are generally the richest ore, and as a result the metallic content of the final sample will be more or less than the average of the original pile, depending upon which two quarters are retained. D. W. Brunton, in a paper entitled "Modern Practice of Ore-Sampling," [a] shows by illustrations and an example the effect of "drawing the center." He takes as an example the reduction of a 2,000-pound lot of ore to 62½ pounds (requiring quartering five times), and supposing that at each stage the sample taken represented 98 per cent of the actual value of the cone, he shows that the final sample would only give 90.3 per cent of the true value of the cone.

After the gross sample has been reduced by the coning, long-pile, and alternate shovel methods to approximately 250 pounds, the sample is further reduced in quantity by the quartering method. Before each quartering, the sample is thoroughly mixed and made into a conical pile, as follows:

Quantities of 125 to 250 pounds are shoveled into a new conical pile by depositing each shovelful of coal on top of the preceding one; quantities less than 125 pounds are placed on a suitable cloth, measuring about 6 by 8 feet, and mixed by raising first one end of the cloth and then the other, rolling the coal back and forth. After the coal is thoroughly mixed it is formed into a conical pile by gathering together the four corners of the cloth. The conical pile is quartered as follows:

The cone is flattened, its apex being vertically pressed down with a shovel or a board, so that each quarter contains the material originally in it. The flattened mass, which should be of uniform thickness and diameter, is then marked off into quarters with a board held edgewise, or a piece of sheet iron, along two lines that intersect at right angles directly under the apex of the original cone. The diagonally opposite quarters are shoveled away and discarded, and the spaces which they occupied brushed clean (Pl. I, *C*, shows the four quarters and the intersecting lines; quarters 1 and 3 will be rejected). The coal remaining is successively mixed, coned, and quartered on the canvas until two opposite quarters are about equal to the quantity (approximately 5 pounds) required to fill the sample container for shipment

[a] Am. Inst. Min. Eng., vol. 40, p. 571, presented at the Spokane meeting, September, 1909.

to the laboratory. If after two opposite quarters are placed in the sampling container, it is found that the container is not compactly filled, the other two quarters should be mixed, coned, flattened, and quartered, and the remaining space in the container then filled by taking equal segments from opposite quarters, using the sampling scoop (p. 21). The two rejected quarters are not thrown into the discard, but are placed in a sampling container, hermetically sealed, and held in reserve at the delivery point until report of analysis of the regular sample is received and settlement made for the coal.

The operations and methods followed in preparing and reducing the gross sample to a quantity convenient for transmittal to the laboratory are diagrammatically shown on page 25. The treatment of the 5-pound sample when it is received by the Bureau of Mines is diagrammatically shown on pages 34 and 35.

Accuracy in reducing the gross samples requires that the coal be crushed as directed, thoroughly and systematically mixed, formed in piles, and accurately divided, either by the alternate-shovel method or by quartering, so that the rejected portions and the retained portions will be uniform in character and weight. Thorough cleanliness must be maintained during the entire operation.

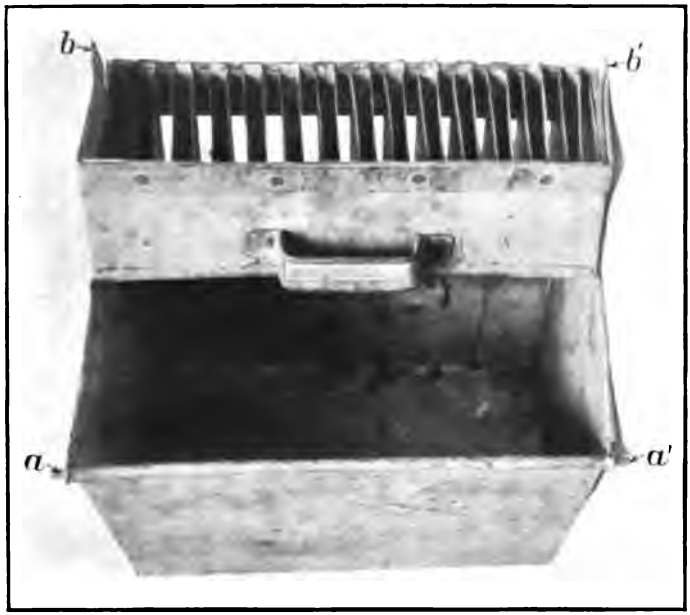
The method of coning and quartering coal and the principles which must be recognized are in essential features as given by Richards [a] for reducing ore samples.

Whenever the different increments of samples are collected throughout some considerable period of time, each increment may be crushed as soon as taken, and the pieces of coal and impurities may be broken sufficiently small to permit two or more reductions of the accumulated samples before further crushing is necessary.

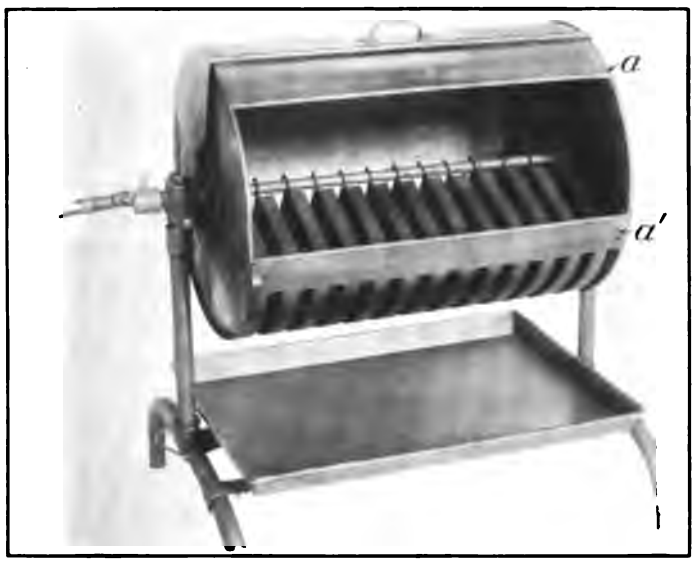
If deliveries extend over a considerable period, what would otherwise be a gross sample may be worked down, as it accumulates, in successive stages to quantities of a size suitable for transmittal to the laboratory, and these fractional samples may be analyzed and the several analyses averaged, or they may later be mixed (at the delivery point or in the laboratory and reduced to one sample) and one analysis made. In averaging analyses or in mixing the several samples, weights should be used in proportion to the tonnages that the fractional samples represent.

If the contract amounts to a considerable quantity, necessitating several samples in relatively short periods, the installation of a crusher has been found in some cases expedient and economical for reducing the gross samples to three-sixteenths inch mesh, or finer, and in such case, instead of the mixing and reducing being done by hand, the reducing buckets or mixing and reducing machine shown in Plate II are used. Even though the contracts are relatively small and

[a] Richards, R. H., Ore dressing, vol. 2, p. 844, and vol. 3, pp. 1574–1578.



A. SAMPLING BUCKET.



B. MIXING AND REDUCING MACHINE.

the samples are crushed by hand, the use of the reducing bucket or machine is recommended. These devices are generally used after the gross sample has been mixed and has been reduced by the "alternate shovel" and quartering method to about 60 pounds.

After the gross sample has been reduced to less than 250 pounds, a shovel takes too large a proportion of the coal, making further reduction by alternate shovelfuls unreliable. The quartering method is used after the sample has been reduced by alternate shovels to approximately 250 pounds, as the capacity of an ordinary shovel is out of proportion to the size of the sample. It may prove desirable in sampling coal containing considerable quantities of free impurities of uneven size to use small shovels of 10 pounds and less capacity in reducing the gross sample by alternate shovels, for as the size of the shovel is diminished the number of fractional parts into which the sample is divided is increased. As the sample becomes smaller, greater precision in quartering is required, and, consequently, refinements in the manner of mixing and reducing should be introduced. The use of buckets or the machine makes thorough mixing possible and the riffles insure accurate division.

A mechanical crusher and mechanical means for preparing the samples for transmittal to the laboratory may be installed and the collection and preparation of the sample can then be made a continuous and purely mechanical process. When mechanical crushers are used the sample should be inspected before or while being fed to the crusher to make certain that the sample does not by chance contain a piece of iron, such as a tie spike or some other highly abrasive substance, accidentally loaded with the coal in the mine and undetected in collecting the sample, otherwise the abrasion of the iron may introduce errors which would alter appreciably the final results.

As it is so important that samples shall be carefully and systematically prepared by a prearranged plan, in order that their analyses will serve as an equitable basis for the determination of the price to be paid for coal purchased under the specification method, the specifications used by the Government give the method of sampling, as described above, in considerable detail. To assure its being clearly understood the method of sampling specified in a contract may be illustrated. The instructions which accompany the specifications given on pages 46 to 58 have been illustrated (Pl. V) to show the hand preparation of samples.

SAMPLING BUCKETS.

When the sampling buckets are used, two similar ones are required. About half of the top of each bucket is covered with a riffle. The coal is placed in one of the buckets, and the projections *aa'* (Pl. II, *A*) of the stiffening rod of this bucket are placed in the notches *bb'*

of the second bucket. The coal that is poured from the first bucket flows to the riffle of the second bucket; every alternate section cut out by the riffle is discarded and the other sections are caught in the second bucket, thus halving the sample. The sample is poured from one bucket to the other until it is reduced to about 5 pounds, but the discarded 5-pound half is placed in a container and kept as the reserve sample.

THE MIXING AND REDUCING MACHINE.

If more thorough mixing than can be done with the buckets is desired, the mixing and reducing machine is used. Plate II, *B*, shows the apron of the cylinder of this machine open for receiving a sample. After the sample is poured in, the apron's position is shifted, *a* being moved to *a'*. The cylinder is then closed and revolved counterclockwise. The closed sides of the riffles plow through and thoroughly mix the coal, and no coal can be discharged through the riffle while the cylinder is revolved in this direction if the level of the coal is below the axis of the cylinder. After the sample has been mixed, the cylinder is rotated one turn clockwise; the coal in the cylinder is then cut by the planes of the riffle and half of it is discharged into the receiving tray. The coal remaining is again mixed by revolving the cylinder counterclockwise. By alternately changing the direction of rotation, the coal is alternately mixed and halved until about 10 pounds remain in the cylinder. The tray is then emptied of the discarded coal and the 10-pound sample mixed and halved, and the 5-pound sample caught in the tray is put in a container and becomes the official sample while the 5-pound sample remaining in the cylinder is put in a container and held as the reserve sample. The interior of the machine is easy of access and should be brushed clean after each sample.

Generally speaking, the use of mechanical means for sampling coal and preparing samples gives more reliable and satisfactory results than hand labor, as the personal equation is partly eliminated.

COLLECTION OF SAMPLES IN THE DISTRICT OF COLUMBIA.

Gross samples are collected from deliveries under Government contracts in the District of Columbia in accordance with the method given in the specifications and as set forth in this paper. Instead of the gross sample being reduced to 5 pounds, as is necessary in the case of deliveries elsewhere, the sample, after it is reduced to 125 to 250 pounds, is placed in galvanized-iron buckets, each large enough to hold about 70 pounds of coal and having a close-fitting lid that can be locked. The locked buckets of coal are immediately delivered to the crushing room in the Bureau of Mines building, where the preparation of the sample for the laboratory is continued.

THE SAMPLING ROOM.

For preparing the samples collected in Washington, after they have been reduced at the delivery point to 125 to 250 pounds, specially designed machinery is installed in the sampling room of the Bureau of Mines plant. The samples are put through a motor-driven hammer crusher which crushes the coal to pass a $\frac{3}{16}$-inch mesh screen.

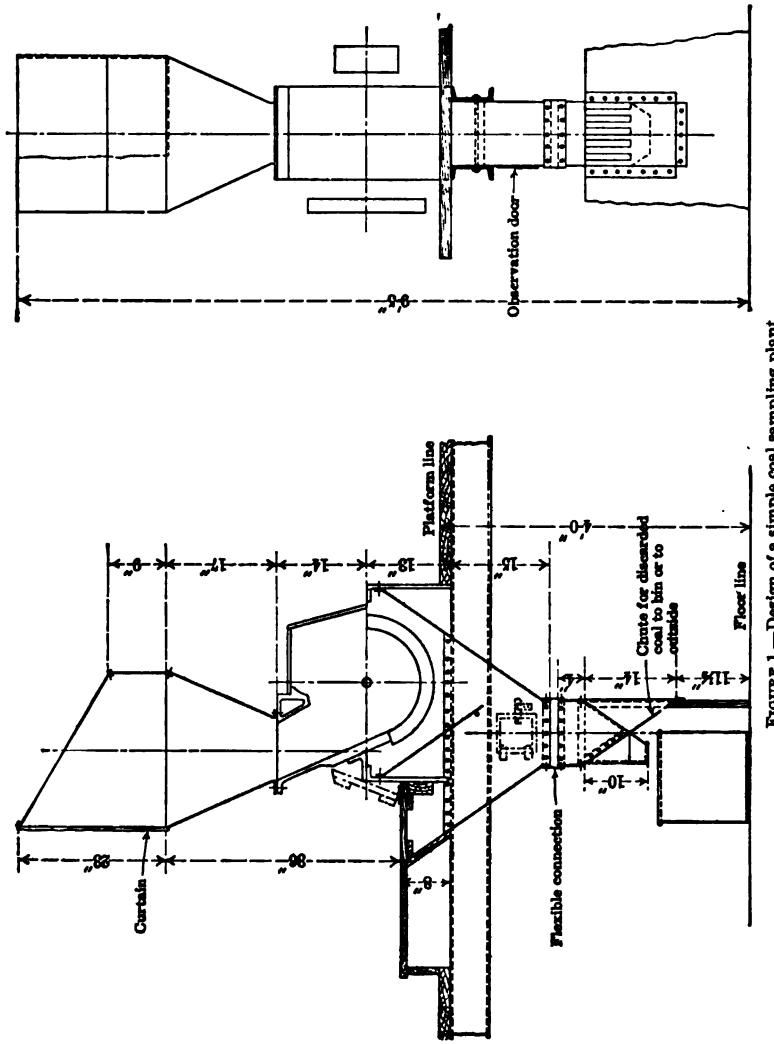


FIGURE 1.—Design of a simple coal sampling plant.

The Bureau of Mines receives from time to time requests from different branches of the Federal service for suggestions as to the type and design of installations for crushing and reducing coal samples. Plate III, *A*, is a view of a simple coal-sampling plant that is largely used by the Bureau of Mines and has been adopted by other bureaus and establishments of the Government. Figure 1 shows the design

of this plant. The riffle is constructed of channel irons and steel plates bolted together. The plan and sections of the riffle are shown in working drawings constituting figure 2. The numbers assigned to the parts shown in this figure are also shown in Plate IV, *A*. A list of the parts used in the riffle, giving the number of each required, follows:

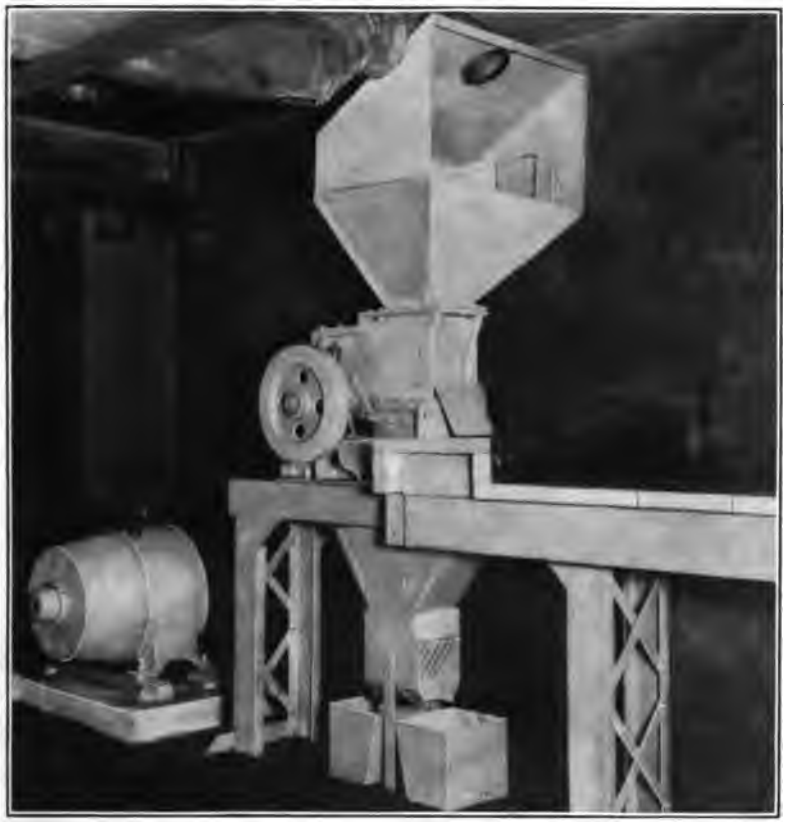
List of parts used in riffle for reducing coal sample.

Piece No.[a]	Material.	Number of pieces required.
1	$\frac{1}{16}$-inch steel plate	9
2	.....do	4
3	.....do	2
4	$\frac{3}{4}$-inch channel, $4\frac{1}{2}$ inches long	12
5	$\frac{1}{2}$-inch steel rod, $10\frac{1}{2}$ inches long	4
6	$\frac{3}{4}$-inch channel, $12\frac{3}{4}$ inches long	12
7	$\frac{1}{2}$-inch steel rod, 11 inches long	1
8	$\frac{1}{2}$-inch by 2-inch flat steel, 2 feet 2 inches long	2

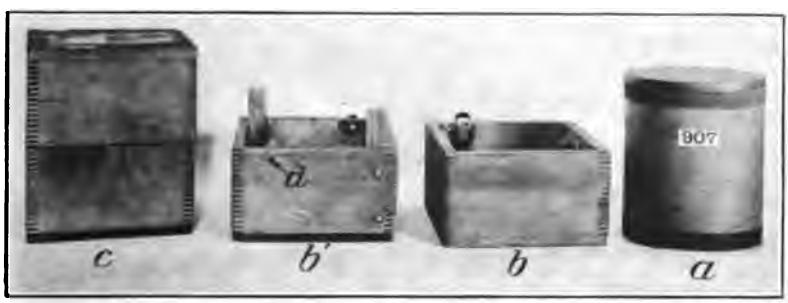
[a] See fig. 2 and Pl. IV, *A*.

The hopper, bin, and other parts through which the coal is passed are made as dust proof as possible and iron cement is used to close leaks. However, more or less free dust arises from the crusher. In the Bureau of Mines sampling plant this dust is carried away by means of a ventilating system, there being an exhaust fan, driven by a direct-connected motor, in a penthouse on the roof of the building. Galvanized-iron ducts lead from the fan to the laboratory and sampling rooms. In the sampling rooms, leading from the main ventilating duct, are branches connecting each bin and hopper, some with hoods placed over dust-producing machines. On each one of these branch ducts, as well as on the main ventilating pipe, dampers are attached by which the draught is regulated. The system is very satisfactory. It keeps the sampling rooms free from dust and prevents any from entering other parts of the building.

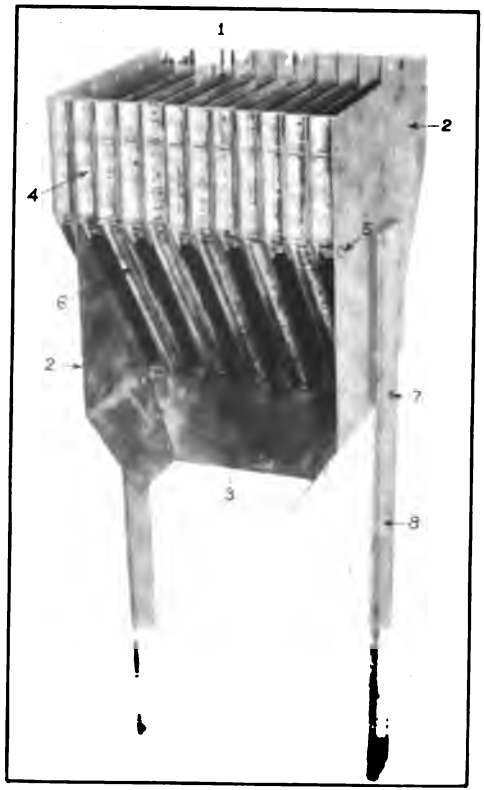
The sample is received in buckets, each holding approximately 70 pounds of coal, and the filled buckets are stored on the platform. Each bucket of coal making up the sample is successively passed through the motor-driven crusher, which reduces the coal to $\frac{3}{16}$-inch mesh and finer (practically all of the coal will pass through $\frac{1}{8}$-inch mesh), and the coal is halved by a riffle, one half being deflected to a bin for discarded coal and the other half into a bucket. As the buckets are emptied into the crusher, they are available for catching the retained half from the riffle. Buckets containing the half of the sample are easily swung to the platform and the sample is again halved in quantity by dumping the coal through the trapdoor (shown in fig. 1) and repassing it over the riffles. Elevating the sample to the platform and halving the sample are repeated until the sample is reduced to the quantity convenient for transmittal to the laboratory.



A. COAL-SAMPLING PLANT.



B. DOUBLE CONTAINER. *a*, PAPER CASE; *b*, *b'*, SECTIONS OF WOODEN BOX; *c*, CONTAINER ASSEMBLED; *d*, HOLE FOR RELEASING CATCH.



A. SAMPLING RIFFLE.

B. SEALING CONTAINER.

Only the relation of one bin wall to the riffle is shown in the drawing; the shape of the bin can be varied to suit the arrangements in the building. If the building in which the installation is housed is so situated that a chute for the discarded coal can lead directly into a wagon body, car, or the boiler room, the disposal of this coal will be simplified.

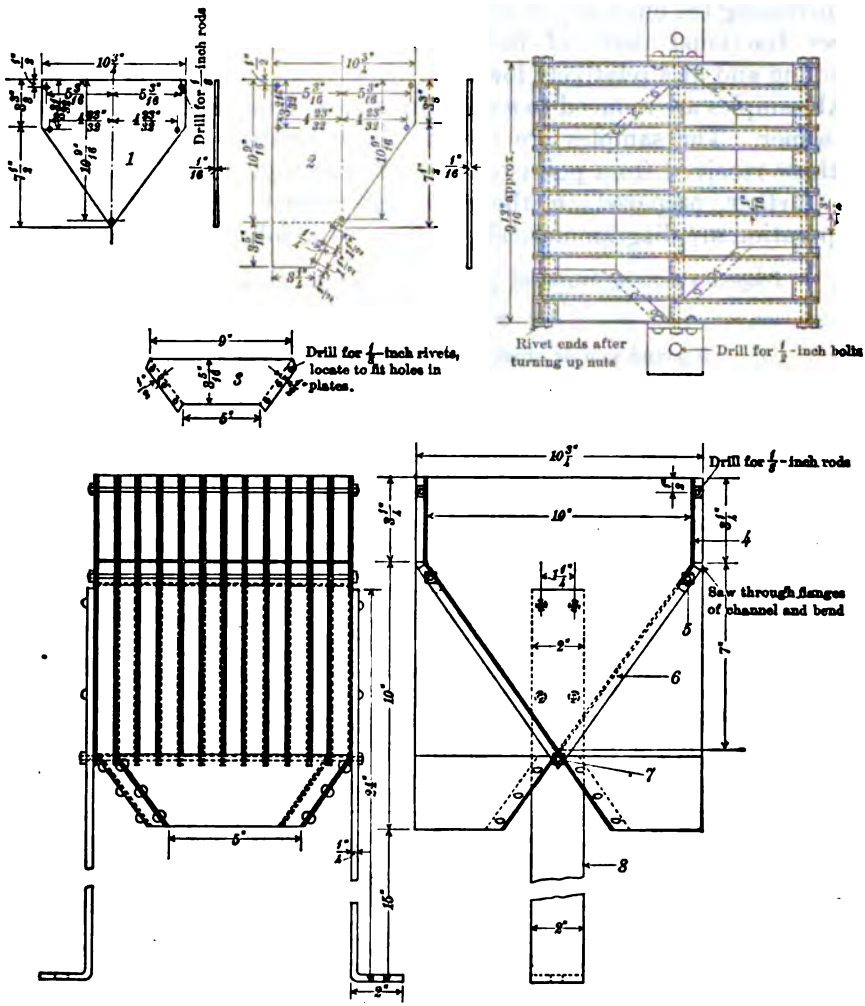


FIGURE 2.—Working drawings for riffle for reducing coal sample.

For the inspection of the riffle and the removal of matter clogging the riffle, a small door is provided in the main hopper. After each crushing the hopper and riffle should be brushed clean.

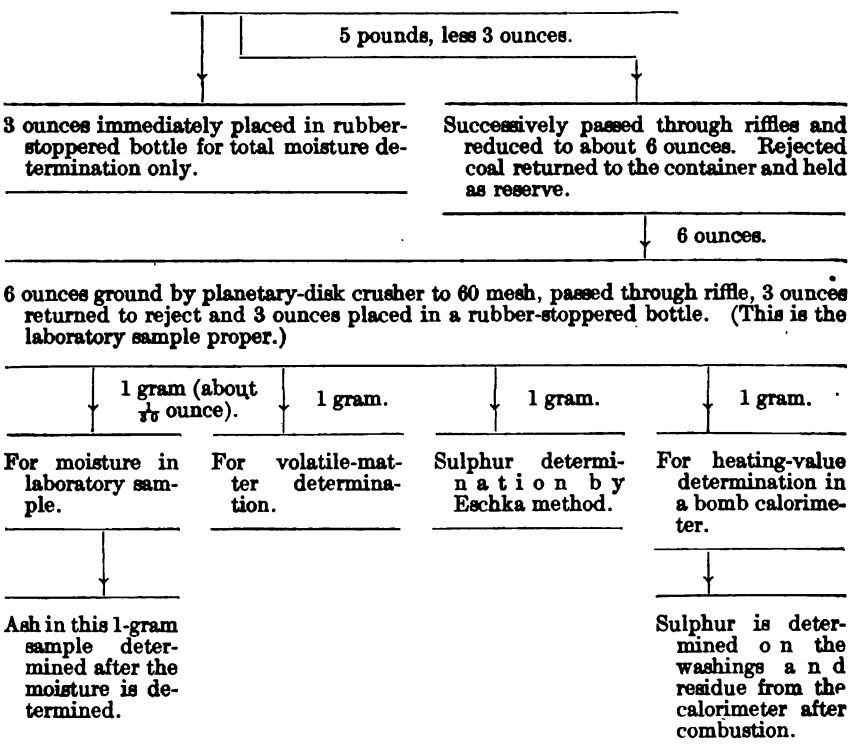
This particular form of equipment was developed with a view to simplicity and cheapness. By placing a series of riffles one below

the other, the sample can be reduced to one-quarter, one-eighth, one-sixteenth, etc., of its original quantity, depending upon the number of riffles installed. As more riffles are added, the cost is increased and the platform must be raised, requiring other means than hand labor for elevating the parts of the samples. The Bureau of Mines is experimenting with other devices and types with a view to increasing the efficiency of the installation so that it will accurately select fractional parts of the gross sample with a minimum of handling and at a relatively low cost.

All samples are reduced to a quantity that will nearly fill a 5-pound container. The samples are then in the same stage of preparation as those received from points outside of Washington, and like them are further prepared in the sampling room.[a] The methods of preparation are diagrammatically shown in the following:

Diagrams showing treatment of the 5-pound sample in the laboratory.

METHOD A.



[a] The method of preparation of the samples in the sampling room, with a description of the laboratory methods and equipment, is given on pp. 74 to 91, Bureau of Mines Bulletin 41.

Diagrams showing treatment of the 5-pound sample in the laboratory—Continued.

METHOD *B*.

5-pound sample dried in air-drying oven for "total moisture" determination.

↓

Crushed by rolls to 20 mesh.

↓

Reduced in quantity by riffles to 8 ounces. Rejected coal returned to the container and held as reserve.

↓

8-ounce sample pulverized to 60 mesh in Abbe ball mill.

↓

8-ounce sample reduced in quantity by riffles to 3 ounces which is placed in a rubber-stoppered bottle and becomes the laboratory sample proper. Rejected coal returned to the container and held as reserve.

↓

3-ounce laboratory sample treated the same as the 3-ounce sample under method *A*.

Both methods of procedure given above are followed in the Bureau of Mines laboratory in Washington, D. C., wherein the samples representing Government coal deliveries are analyzed and tested—method *B* being followed for most anthracite samples and for any samples of high-moisture or wet coals, as by this method a more representative moisture value can be obtained than by method *A*, for in method *A* high-moisture or wet coals unavoidably lose more or less moisture in the crushing of the 5-pound sample. Method *B*, somewhat modified,[a] is followed on all samples in the Bureau of Mines laboratory in Pittsburgh, Pa., which is maintained for analyzing and testing samples necessary for the conducting of certain fuel, mining, and metallurgical investigations which the bureau is making.

SEALING AND MAILING.

The final 5-pound sample is immediately placed in the container furnished by the Bureau of Mines and sealed air-tight. The coal should be firmly packed in the container, so as to occupy as much of the space as possible, as in this way the air is more nearly excluded. This packing is best accomplished by having the coal finely crushed in the manner described in the preceding pages and by shaking or jarring the container repeatedly and vigorously while filling it.

[a] Stanton, F. M., and Fieldner, A. C., Methods of analyzing coal and coke: Tech. Paper 8, Bureau of Mines, 1913, 42 pp.

Two coal-sample containers have been developed by the Bureau of Mines, one a galvanized iron can and the other a double container, consisting of a wooden shipping box and an inclosed pressed-paper case.

The metal can is 11 inches long and 3⅛ inches in diameter (inside dimensions), with a screw cap 2 inches in diameter. Its edges are crimped and carefully soldered, so as to make it air-tight and strong. The screw cap has a washer of rubber, or other flexible material, to exclude the air. As a further protection and to insure tightness, the cap, when in place and screwed down, is wrapped carefully with several layers of adhesive tape, the first layer of which completely covers the joint between the lower edges of the cap and the neck of the can. In Plate IV, *B*, *a* shows the first layer of the tape being forced down with thumb and forefinger, and *b*, the can properly sealed. It is not advisable to use solder, paraffin, or sealing wax of any kind, because some of the material may become mixed with the coal, either when it is applied or when the cap is removed. Before it is filled, each can should be carefully inspected as to tightness and freedom from rust.

The capacity of the can is 2½ to 3 pounds of coal, and as the quantity required for transmittal to the laboratory is 5 pounds, two of the cans are used for each sample. After the sample has been reduced to a quantity that will about fill two cans, it should be thoroughly mixed and divided into two parts and one put in each can. Bureau of Mines Form 6–220, used for furnishing data concerning the sample (p. 38) is filled in for each can, and the form is placed (not pasted) around the can. Each form shows the number of the can which carries the other half of the sample. As a safeguard against the can opening in transit and the coal damaging the contents of a mail sack, each can is wrapped with several thicknesses of heavy manila paper. An addressed franked wrapper is pasted on or tied around the wrapped can.

The double container is shown in Plate III, *B*, in which *a* is the pressed "damptite" paper case, *bb'* the two sections of the wooden box; *c* is the container assembled.

The box is opened by inserting a nail, or any pointed instrument, in the two holes in opposite sides of the box (one being shown, *d*). This pointed instrument should not be inserted too far, as it would perforate the paper case, but only far enough to release the spring catches which hold the two halves of the box together, so that the upper half of the box can be lifted off.

The pressed paper case is 5⅞ inches total diameter and 7 inches long over all, and has a capacity of 5 to 7 pounds of coal. The shipping box is made of sound, well-seasoned basswood, free from knots, checks, and doaty places, and is made strictly in accordance with

specifications, as regards thickness of the material, number of nails, inside dimensions, arrangement of corners, catches, finish, etc. The corners are made lock-jointed, each being glued throughout its full length by dipping the joints in glue before assembling. They are further reinforced by small finishing nails driven through the tenons of each corner, so that the box is thoroughly substantial. One part of the box has two corner blocks of specified dimension and form, which are glued through their length into the corners of the box and riveted. Two special suit-case catches are used, which are placed on the inside of the box near opposite corners and so situated that they will operate in either of the two possible ways of assembling the box. The small holes are so drilled through each side of the box and through the small part of the catch lug that the catches are readily released when a pointed instrument is inserted in the holes.

The sample of coal is placed in the paper case, and the edge of the cap is wrapped with electrician adhesive tape so as to seal the paper case as nearly air-tight as possible. Form 6–220, properly filled in with data concerning the sample, is placed (not pasted) around the case, and the case is then placed in the box and the box assembled. An addressed shipping tag is pasted or tacked onto the box.

The blank form referred to is in two sections—an original and a duplicate. The original form accompanies the sample, furnishes the bureau complete information as to the sample, and becomes the bureau's permanent record. The duplicate is used as a file copy for the office submitting the sample.

Special attention should be given to filling out the form and promptly forwarding the sample. Failure to fill out the form properly or to place it around the container may cause indefinite delay in making the analysis of a sample and in reporting the results.

A letter should be written informing the bureau that a sample or samples (container numbers stated) have been forwarded. As the tonnage on many orders or deliveries during a month may be considerable, and as samples may be submitted from time to time, unless the bureau is informed it has no knowledge whether all samples have been received to represent the tonnage, nor has it any intimation as to which is the first or last sample, although this information is necessary to insure prompt reports. To furnish the necessary information, it should be stated in the letter, as follows:

This is the first and only sample which will be submitted on order No. ——, or of the deliveries during the month of ———.

Or,

This sample is the —— (give number) one submitted on order No. ——, or of the deliveries during the month of ———, and other samples on this order or month's delivery will be submitted.

Or,

This is the last sample on order No. ————, or of the deliveries during the month of ————, and is to be considered with samples submitted in containers numbered ———.

If a sample is submitted representing coal from a mine or from a source other than that specified in the contract, the letter transmitting the sample should so state, in order that the records of the Bureau of Mines will be complete.

A copy of the front and reverse sides of the two sections comprising the form mentioned above are herewith given.

[Original, front.]

6-220 DEPARTMENT OF THE INTERIOR.

BUREAU OF MINES.

Coal delivered to .....
(Institution. If ship or barge, state where loaded.)
Container number ..... Sample number.....
(Serial number of institution mailing sample.)
Name of contractor .....
Coal, kind and size .....
Number of tons represented by this container .....
Date of delivery ..... Date of mailing sample .....
Contract number ..... Order number .....
Is this the only sample on this order or month's delivery? .....
(Answer yes or no.)
If not, is this the first, second, etc., or last sample? .....
If this is the *last* of several samples, state total tonnage delivered under this order or month's delivery .....tons.
Original. (Signed) .....

[Original, back.]

SUGGESTIONS AS TO FILLING AND SEALING CONTAINERS.

The coal sample should be firmly packed in the container so as to occupy as much of the space as possible, since in this way the air is more nearly excluded. To insure the tightness of the container, the cap when in place should be wrapped carefully with several layers of adhesive tape, the first layer of which should completely cover the joint between the lower edge of the cap and the neck of the container. It is not advisable to use solder, paraffin, or sealing wax of any kind, because some of the material may be mixed with the coal either when the material is applied or when the cap is removed. Before being filled each container should be carefully inspected as to tightness and freedom from foreign matter. Any containers rendered defective in transit should be returned empty. The Bureau of Mines will furnish a supply of containers and of this form on request.

[For instructions as to use of this form, see instructions on back of attached (duplicate) section.]

[Duplicate, front.]

6-220 DEPARTMENT OF THE INTERIOR.

BUREAU OF MINES.

Coal delivered to.....
(Institution. If ship or barge, state where loaded.)
Container number..... Sample number.....
(Serial number of institution mailing sample.)
Name of contractor.....
Coal, kind and size.....
Number of tons represented by this container.....
Dates of delivery..... Date of mailing sample.....
Contract number..... Order number.....
Is this the only sample on this order or month's delivery?.....
(Answer yes or no.)
If not, is this the first, second, etc., or last sample?.....
If this is the *last* of several samples, state total tonnage delivered under this order or month's delivery.....tons.
Duplicate. (Signed).....

[Duplicate, back.]

INSTRUCTIONS AS TO THE USE OF THIS FORM.

Fill out this form for each sample of coal forwarded to the Bureau of Mines. The office filling out the form is to retain the *duplicate* copy. The original must be placed around the container (but not pasted to the container; it may be held in place by a rubber band) in such a manner that the sample and the information regarding it can not be separated in mailing. This form must be properly filled out and forwarded in order to expedite testing and reporting. A letter should be written informing the bureau that sample or samples (giving container numbers) have been forwarded. The receipt of the sample will be immediately acknowledged.

[For suggestions as to filling and sealing containers, see back of attached (original) section.]

REPORTING ANALYSES.

The analyses and tests of samples are reported by the laboratory to the fuel-inspection section, where the record of the samples is kept. The laboratory receives the samples with an identification number only, which is given the sample when the sample is received from the mail, and the laboratory reports the analysis and test by number only. If a report is to be based on the analyses of two or more samples, the analyses are averaged, each analysis being given a weight according to the proportion of the total tonnage which it represented. The results are then reported in triplicate on the following letter form to the branch of the service submitting the sample or samples, which in turn furnishes the contractor one of the copies:

DEPARTMENT OF THE INTERIOR.

BUREAU OF MINES.

Washington, D. C., ...

SIR: In reference to the..... tons of ..... coal delivered on your contract No. ..... and your order No. ..... to the..... ....., 191 , by.....

The analysis of the samples of coal received by the Bureau of Mines was as follows:

	As received.	Dry coal.
Moisture.....		
Volatile matter.....		
Fixed carbon.....		
Ash.....		
Total		
Sulphur.....		
British thermal units.....		

This information is for the use of the Government and the dealer or operator furnishing the coal. It i confidential until it is published by the United States Government.

Remarks:

Certified: Respectfully,

....

Engineer in charge Fuel Inspection. *Director.*

COAL SPECIFICATIONS AND PROPOSALS.

There are given in the following pages coal specifications and proposals typical of those in use by the Government for the purchase of coal under specifications based on the heating value, the content of ash and of moisture, and other considerations.

The method for sampling[a] is not printed as an integral part of the specifications, but as a separate appendix. It is published in a larger edition than the specifications, so that all officials charged with the duty of collecting samples may be supplied with copies.

Two classifications of the coal purchased are made, namely, (*a*) coal for steam power and heating plants, which include bituminous (semibituminous, subbituminous, lignite) and the small sizes of anthracite (pea and buckwheat), and (*b*) the large sizes of anthracite (broken, egg, chestnut, and stove), which are used in small house-heating furnaces and stoves for heating and domestic uses.

The purpose of the specifications is to clearly set forth the character and quality of coal desired, to obtain bids which fully specify

[a] The Government method of sampling coal is quite similar to the tentative standard method of the American Society for Testing Materials (Am. Soc. Testing Materials: Yearbook, 1915, p. 591).

the coal offered, the values offered in the case of power and heating coals by the successful bidder becoming a part of the contract, to furnish means whereby the Government may be assured of receiving the coal contracted for, providing for a definite procedure for determining equitable settlement for coals differing in character and quality, and to include concise statements of the necessary legal phases, etc., all with the view that the specifications and proposal signed by the successful bidder may become a contract which will work to the advantage and justice of both the Government and the contractor.

Attention is especially directed to instructions for sampling given in the specifications which become a part of the contract. Prior to the fiscal year 1912–13 the method of sampling was given scant mention, leaving one of the most important features determining the successful and satisfactory application of the specification method of the purchase of coal almost wholly in the hands of the purchaser, the seller having little or no means whereby he could exercise a control of the manner and method of collecting and preparing samples that should represent the coal furnished. It is as essential that an established and an agreed-upon method of sampling be followed, as it is that the sample be analyzed by a reputable laboratory; in fact, the sampling is of first consequence, for if a sample is haphazardly taken and carelessly reduced to a quantity convenient for transmittal to the laboratory, and hence is nonrepresentative, it is usually impossible or impracticable to get another sample; whereas if the analysis and test of a representative sample are in error, the remaining part of the sample can be analyzed and tested, by another laboratory if desired. Unwarranted corrections in price and resulting injustice and hardship to the buyer or seller may easily and unintentionally occur through lack of perception of the relative importance of sampling and the observance of proper methods of collecting and preparing samples. By clearly setting forth the method of sampling as a part of the contract, the seller or the buyer has something tangible on which to base legitimate complaints if samples are not properly collected and prepared. Such is the purpose of putting in the Government specifications the method of sampling in some detail.

As the specifications given herein are so general, applying generally to all coals purchased by the Government under every condition of delivery, it is impossible to state therein more specific directions for sampling, but for any particular conditions of delivery more definite directions can be prepared and proper consideration for the character of the coal given. By observance, however, of the general directions for sampling, which are given in the specifications that follow, samples

that are fairly representative of the coal sampled can be obtained without difficulty.

Though a contract may be let under the specification basis, the sampling of small orders of, say, 50 tons or less, may be discretionary with the Government, a provision to this effect appearing in the contract. If samples are not taken the bid price per ton is paid. This discretionary right of sampling small orders or tonnages makes it unnecessary to sample small deliveries under one large general contract of from a half to a few tons to small launches or boats, or to different quarters or buildings where facilities for sampling or storing accumulated samples are not at hand. It is obvious that the expense of collecting and preparing a sample to represent such small tonnages, together with the cost of analysis, would make the unit cost per ton ordinarily prohibitive and disadvantageous.

Under "Price and Payment" for bituminous coal (p. 51), 2 per cent variation from the guaranteed standard of British thermal units (B. t. u.) is allowed before price corrections. On 14,000 B. t. u., "dry coal," this means that there is no price correction for delivered coal of an apparent heating value as reported by the laboratory between 13,720 and 14,280. This is allowed to provide (*a*) for the reasonable variations that, it is recognized, may be obtained with the same 5-pound sample in two different determinations in the same laboratory, (*b*) for variations that result in preparing and reducing the gross sample to a quantity convenient for transmittal to the laboratory, (*c*) for variations due to the collection of gross samples as representing the coal sampled, and (*d*) for allowing the contractor latitude in the preparation of the coal, as it is recognized that the quality of his coal expressed in terms of ash and B. t. u. can not be controlled within strictly narrow limits.

In interpreting a heating value determination, then, the value reported by the laboratory must be considered as the apparent value of the coal sampled, as the actual value of the coal may have been more or less than the apparent value because of the variations above cited. If the reported value differs by more than 2 per cent from the guaranteed standard, the result is considered as evidence that coal of a quality other than that contracted for was delivered and the price is corrected accordingly. If a number of gross samples are taken to represent a total quantity of coal delivered, and a report is obtained by averaging the several analyses and tests, the apparent value reported by the laboratory may be within 1 per cent or less of the actual value of the entire quantity, but in specifications as general as those given herein a 2 per cent variation from the standard is considered more equitable and will eliminate frequent and unwarranted price corrections, especially if payment for a delivery or order is based on a single determination. In the sampling of cargo shipments to the

Isthmus of Panama (p. 19) the reported results between two separate and independent series of samples representing the same cargo agree on an average within less than 50 B. t. u. The samples are collected by experienced collectors and prepared very systematically, and the reported results for a cargo are determined by averaging a number of analyses. With such sampling the variations above enumerated are largely averaged and eliminated, and the variation that may be allowed before price corrections may, under such conditions, be reduced to 1 per cent or even less.

It is not the intent of the specifications continually to make corrections in price for slight variations of the actual heating value from the guaranteed standard, and it is desired to eliminate corrections which are unwarranted because of the difference between the reported apparent heating value and the actual heating value, the first purpose of the specifications being to insure that the Government is receiving coal similar within reasonable limits to the standard of the contract.

The power and heating plant specifications require the bidder to specify the quality of coal offered in terms of moisture, "as received," ash, sulphur, volatile matter, and B. t. u., "dry coal;" these values becoming the standards of the contract to determine rejectable coal and the price to be paid for delivered coal. Bidders have in some cases specified a higher B. t. u. value and a lower ash content than the quality of the coal warranted, upon the theory that the high B. t. u. and low ash values would give them an advantage in the comparison of bids. The bid price may be correspondingly higher, the bidder presumably expecting a deduction to be made and to receive a price on his delivered coal lower than the bid price. The apparent price may be, therefore, higher than the actual price received, and use may be made of the apparent price for advertising purposes. Bidders are cautioned against offering higher standards than can be maintained on an average, for to do so may result in the bid being rejected (see sec. 8, p. 47, of the specifications), or may result in excessive penalties, the purchase of coal in the open market, the difference in cost of coal so purchased being charged against the contractor, or may lead to the cancellation of the contract (see sec. 30, p. 50).

By reference to the specifications for anthracite, broken, egg, stove, and chestnut sizes, it will be noted that bidders are not required to specify the quality of the coal in terms of ash, B. t. u., moisture, sulphur, and volatile matter, and that regular and systematic sampling of all deliveries is not required to determine the price to be paid for each and every delivery. The specifications provide, however, for the sampling of coal that proves unsatisfactory because of excessive ash or clinkering and for price corrections if the ash as shown by analysis is in excess of a permitted variation from the standard

for the particular size of coal, these standards being determined from hundreds of ash determinations made during a period of six years. B. t. u. standards are not used, as it has been determined that the heating value for the different sizes is, in the main, a function of the ash content, varying inversely and in proportion with the ash; that is to say, if the ash content is increased, for example, 1 per cent, the heating value is decreased 1 per cent.

Because of economic considerations and the physical character of anthracite, the specifications used for bituminous and the small sizes of anthracite coal requiring sampling are not adapted for the purchase of the large sizes of anthracite. Most of the Government contracts for these sizes are for relatively small yearly tonnages with deliveries of ½ ton to 50 tons, but seldom more to a building. To collect regularly samples from such small deliveries would make the unit cost per ton of sampling prohibitive, the cost being generally greater than any probable saving. To obtain samples that would fairly represent the quality of these coals would require collecting samples of 1,000 to 1,500 pounds, or more, and to obtain a final sample for analysis that would represent the gross sample within reasonable limits would require crushing and recrushing the gross sample, thereby perhaps destroying the value of the gross sample for use in a house-heating furnace or stove, and largely wasting it, unless a Government steam-power plant were available in which it could be advantageously burned. The total or partial loss in value of 1,000 or 1,500 pounds of coal at $5 to $10 per ton from a small delivery is manifestly a matter deserving consideration. Owing to the hardness and brittleness of anthracite, the crushing of a gross sample by hand is difficult and tedious and requires hours of labor; in fact, a mechanical means of crushing is almost absolutely necessary, but the cost of the necessary equipment would prove prohibitive in the case of small contracts.

Because of the above facts, as well as the manner in which anthracite is prepared at the colliery and the small area of the Pennsylvania anthracite fields, and because of other considerations, the Government does not consider the application of the specifications which are adapted for bituminous coal generally suitable for the purchase of the large sizes of anthracite. The specifications that are used provide for the acceptance and use of coal and payment at contract price so long as no difficulty is experienced, and the collection of samples is necessary only as set forth in the specifications.

Anthracite is graded into sizes before shipment, and each grade commands a certain price. The size of the openings in screens and the types of screens used in preparing the sizes may vary slightly; however, the following table indicates the commercial sizes of anthracite:

Sizes of anthracite.

Sizes.	Prepared with square-mesh screens.		Prepared with round-mesh screens.	
	Through meshes having opening of—	Over meshes having opening of—	Through meshes having diameter of—	Over meshes having diameter of—
	Inches.	*Inches.*	*Inches.*	*Inches.*
Broken (furnace)	4	2¾	4½	3½
Egg	2¾	2	3½	2½
Stove	2	1⅝	2½	1½
Nut (chestnut)	1⅝	¾	1½	⅞
Pea	¾	½	⅞	7/16
Buckwheat No. 1	½	¼	7/16	5/16
Buckwheat No. 2, or rice	¼	⅛	5/16	7/16
Buckwheat No. 3, or barley			7/16	7/16

SPECIFICATIONS AND PROPOSALS FOR BITUMINOUS AND ANTHRACITE COAL.

.....
(Office issuing the proposals.)

.....
(Place.)

.....
(Date.)

I. PROPOSALS.

Date to be delivered.

1. Sealed proposals, in duplicate, on blank forms supplied by the ....., to furnish such quantities of coal as specified herein as may be required for use of the ....., for the fiscal year ending June 30, 191.., will be received until 2 o'clock p. m., ..., at the office of the ....., and then opened.

Bidder may be present.

2. Each bidder shall have the right to be present, either in person or by attorney, when the bids are opened.

Address of proposals.

3. Proposals, in duplicate, must be forwarded to the..... ....., postage prepaid. Addressed envelope for mailing is inclosed herewith.

Form and signature.

4. Proposals must be made in duplicate on the form given herein, and must be signed by the individual, partnership, or corporation making the same; when made by a partnership, the name of each partner must be signed. If made by a corporation, proposals must be signed by the officer thereof authorized to bind it by contract, and be accompanied by a copy, under seal, of his authority to sign.

Cash or certified check.

5. The proposals must be accompanied by cash or by certified check drawn payable to the order of the ....., in the amount equal to 2 per cent of the estimated amount involved for the fuel for which bids are submitted, the minimum amount in any case to be $10. This requirement is solely to guarantee, if the award is made on the proposal, that within 10 days after notice is given that an award has been made, the bidder will enter into a contract in accordance with the terms of the proposal and execute a bond for the faithful performance thereof, with good and sufficient sureties as hereinafter required. In the event of the failure of the bidder to enter into contract or execute bond, the cash or check guaranty will be forfeited.

II. CONTRACTOR'S BOND.

Sureties.

6. Each contractor shall be required to give a bond, with two or more individual sureties or one corporate surety duly qualified under the act of Congress approved August 13, 1894, in which the contractor and the sureties shall covenant and agree that, in case the said contractor shall fail to do or perform any or all of the covenants, stipulations, and agreements of said contract on the part of the said contractor to be performed as therein set forth, the said contractor and his sureties shall forfeit and pay to the United States of America any and all damages sustained by the United States by reason of any failure of the contractor fully and faithfully to keep and perform the terms and conditions of

his contract, to be recovered in an action at law in the name of the United States in any proper court of competent jurisdiction. Such sureties (except corporate sureties) shall justify their responsibility by affidavit showing that they severally own and possess property of the clear value in the aggregate of double the amount of the above-mentioned forfeiture over and above all debts and liabilities and all property by law exempt from execution; the affidavit shall be sworn to before a judge or a clerk of a court of record or a United States attorney, who must certify of his own personal knowledge that the sureties are sufficient to pay the full penalty of the bond.

May be waived.

7. If the estimated amount involved in the contract does not exceed the sum of $200, then the bond may be waived with the consent of the department involved.

III. RESERVATIONS.

Rejection of bids.

8. The right is reserved by the Government to reject any and all bids and to waive technical defects. Bidders are cautioned against guaranteeing higher standards of quality than can be maintained in delivered coal (this applies especially to bituminous coal and the steam sizes of anthracite), as the Government reserves the right to reject any and all bids, if the Government has information regarding analyses and test results that indicate that higher standards have been offered than probably can be maintained.

Tests.

9. The right shall be reserved by the Government to purchase for the purpose of making boiler tests other coal than that herein contracted for, provided the amount so purchased shall not exceed 10 per cent of the estimated consumption during the period covered by this agreement.

Lowest bids may not be considered.

10. If it should appear to be to the best interests of the Government to do so, the right is reserved to award the contract for supplying coal at a price higher than that named in a lower bid, or in lower bids.

Failure to contract.

11. If the bidder to whom the award is made shall fail to enter into a contract as herein provided, then the award may be annulled and the contract let to the next most desirable bidder without further advertisement, and such bidder shall be required to fulfill every stipulation expressed herein, as if he were the original party to whom the contract was awarded; provided, however, that such bidder is notified of said award within 60 days after the date on which the bids on this contract were opened. If such notice should not be given within said 60 days, then the acceptance of the award will be optional with the said bidder.

Contracts nontransferable.

12. No contract can be lawfully transferred or assigned.

Default.

13. No proposal will be considered from any person, firm, or corporation in default of the performance of any contract or agreement made with the United States, or conclusively shown to have failed to perform satisfactorily such contract or agreement.

IV. QUANTITY.

14. The estimated quantity of coal in ..... tons of 2,000 pounds to be purchased is based upon the previous annual consumption, but the right will be reserved to order a greater or less quantity, subject to the actual requirements of the service.

V. DELIVERY.

Quantity, time, and place. 15. The coal shall be delivered in such quantities at such times as the Government may direct. (Place of delivery to be stated.)

Rapidity. 16. All the available storage capacity of the Government coal bunkers shall be placed at the disposal of the contractor to facilitate delivery of coal under favorable conditions. When an order is issued for coal, the contractor upon commencing a delivery on that order shall continue the delivery with such rapidity as not to waste unduly the services of the Government inspector.

Failure to deliver. 17. After verbal or written notice shall have been given to deliver coal under this contract a second notice may be served in writing upon the contractor to make delivery of the coal so ordered within a reasonable time, to be determined by the Government official in charge, after receipt of said second notice. Should the contractor for any reason fail to comply with the second request, the Government shall be at liberty to buy coal independent of this contract, and for coal so purchased to charge against the contractor and his sureties any excess in price over the price which would have been paid to the contractor had the coal been delivered by him.

Hours. 18. The contractor shall be allowed to deliver coal during the usual hours of teaming—that is, between 8 a. m. and 5 p. m.

Weighing. 19. (To be stated by whom and where the coal shall be weighed, etc.)

VI. SAMPLING.

Contractor privileged to be present. 20. The contractor shall have the privilege of having a representative present to witness the collection and preparation of the samples to be forwarded to the laboratory.

Method. 21. The samples shall be collected and prepared in accordance with the method given in Appendix A, attached hereto as a part of these specifications and proposals.

VII. ANALYSES.

Laboratory and thod. 22. The samples shall be immediately forwarded to the Bureau of Mines, Department of the Interior, Washington, D. C., and they shall be analyzed and tested in accordance with the method recommended by the American Chemical Society and by the use of a bomb calorimeter. Such analyses and tests shall be made at no cost to the contractor. The results shall be reported by the Bureau of Mines in not more than fifteen (15) days after the receipt of the sample. If more than one sample is received from the same delivery, the fifteen (15) days shall date from the receipt of the last sample taken.

VIII. BITUMINOUS AND ANTHRACITE PEA AND BUCKWHEAT COAL FOR POWER AND HEATING PLANTS.

DESCRIPTION OF COAL DESIRED.

Kind and quality. 23. The coal must be a good coal..... (kind and size to be specified), and must be adapted for successful use in the particular furnace and boiler equipment.

Information to be supplied by bidder. 24. Bidders are required to specify the coal offered in terms of moisture in the coal "as received," and of ash, volatile matter, sulphur,

and British thermal units in "dry coal," such values to become the standards for the coal of the successful bidder. In addition, the bidders are required to give the trade name of the coal offered, the name or other designation of coal bed, name of mine or mines, location of mine or mines (town, county, and State), railroad on which mine or mines are located, and name of operator of mine or mines. This information shall be furnished in spaces provided hereinafter.

NOTE.—Bids not supplying the foregoing information may be considered informal and rejected.

Coal of the description and analysis specified is herein known as coal of the contract grade. Bidders are cautioned against specifying higher standards than can be maintained, for to do so will result in deductions in price and may result in the rejection of delivered coal or the cancellation of the contract. In this connection it should be recognized that the small "mine samples" usually indicate a coal of higher economic value than that actually delivered in carload lots, because of the care taken to separate extraneous matter from the coal in the "mine samples."

AWARD.

Considerations.

25. In determining the award of this contract consideration will be given to the quality of the coal (expressed in terms of moisture in coal "as received," of ash in "dry coal," and British thermal units in "dry coal") offered by the respective bidders and to the operating results obtained with the same and with similar coals on previous contracts or by test, as well as to the price per ton.

Bids subject to rejection.

26. Bids may be rejected from further consideration if they offer coals regarding which the Government has information that they possess unsatisfactory physical characteristics or volatile matter or sulphur or ash contents, or that they are unsatisfactory because of clinkering or excessive refuse, or because of having failed to meet the requirements of city smoke ordinances, or for other cause that would indicate that they are of a character or quality that the Government considers unsuited for the storage space or the furnace equipment of the particular contract.

Method of comparing bids.

27. In order to compare bids as to the quality of the coal offered, all proposals shall be adjusted to a common basis. The method used shall be to merge the four variables—moisture content, ash content, heating value, and price bid per ton—into one figure, the cost of 1,000,000 British thermal units. The procedure under this method shall be as follows:

(*a*) All bids shall be reduced to a common basis with respect to moisture, by dividing the price quoted in each bid by the difference between 100 per cent and the percentage of moisture guaranteed in the bid. The adjusted bids shall be figured to the nearest tenth of a cent.

(*b*) The bids shall be adjusted to the same ash percentage by selecting as the standard the proposal that offers coal containing the lowest percentage of ash. The difference in ash content between any given bid and this standard shall be divided by 2 and the price in such bid, adjusted in accordance with the above, multiplied by the quotient. The result shall be added to the above adjusted price. The adjusted bids shall be figured to the nearest tenth of a cent.

(c) On the basis of the adjusted price, allowance shall then be made for the varying heat values by computing the cost of 1,000,000 British thermal units for each coal offered. This determination shall be made by multiplying the price per ton adjusted for ash and moisture contents by 1,000,000, and dividing the result by the product of 2,000 multiplied by the number of British thermal units guaranteed. If the coal is purchased on the basis of 2,240 pounds to the ton, the factor of 2,240 should be used instead of 2,000.

Service test.

28. After the elimination of undesirable bids, the selection of the lowest bid of those remaining on the basis of the cost per 1,000,000 British thermal units may be considered by the Government as a tentative award only, the Government reserving the right to have practical service test or tests made under the direction of the Bureau of Mines, the results to determine the final award of contract. The interested bidder or his authorized representative may be present at such test.

CAUSES FOR REJECTION.

Coal subject to rejection.

29. It is understood that coal containing 3 per cent more moisture, or 4 per cent more ash, or 3 per cent more volatile matter, or 1 per cent more sulphur, or 4 per cent fewer British thermal units than the specified guaranties as to the standards for the coal hereunder contracted for, or coal furnished from a mine or from mines other than herein specified by the contractor, unless upon written permission of the Government, shall be considered subject to rejection, and the Government may, at its option, either accept or reject the same. Should the Government have consumed a part of such coal subject to rejection, such consumption shall not impair the Government's right to cause the contractor to remove the remainder of the delivered coal subject to rejection.

Cancellation of contract—open market purchases

30. It is agreed that if the contractor shall furnish coal in three consecutive deliveries, or in case more than 20 per cent of the coal delivered to any date during the life of this contract shall contain 3 per cent more moisture, or 2 per cent more ash, or 3 per cent more volatile matter, or 1 per cent more sulphur, or 2 per cent fewer British thermal units than the specified guaranties as to the standards for the coal hereunder contracted for, or if coal is furnished from a mine or from mines other than herein specified, unless upon the written permission of the Government, then this contract may, at the option of the Government, be terminated, or the Government may, at its option, purchase coal in the open market until it may become satisfied that the contractor can furnish coal equal to the standards guaranteed, and the Government shall have the right to charge against the contractor any excess in price of coal so purchased over the corrected price that would have been paid to the contractor had the coal been delivered by him.

Removal of rejected coal.

31. The contractor shall be required to remove, without cost to the Government, within 48 hours after notification, coal that has been rejected by the Government. Should the contractor not remove rejected coal within the said 48 hours, the Government shall then be at liberty to have the said coal removed from its premises and to dispose of such coal by sale, as the Government shall elect. The proceeds from such sale, less all costs incidental to its removal and to the sale, shall be paid over to the contractor.

PRICE AND PAYMENT.

32. The Government hereby agrees to pay the contractor within thirty (30) days after the completion of an order or delivery for each ton of 2,000 pounds of coal delivered and accepted in accordance with all the terms of this contract, the price per ton determined by taking the analysis of the sample, or the average of the analyses of the samples if more than one sample is analyzed, collected from the coal delivered upon the basis of the price herein named, adjusted as follows for variations in heating value, ash content, and moisture content from the standards guaranteed herein by the contractor. (See paragraph 13 in appendix for exception to this method:) Determination of price.

(*a*) Considering the coal on a "dry-coal" basis, no adjustment in price shall be made for variations of 2 per cent or less in the number of British thermal units from the guaranteed standard. When the variation in heat units exceeds 2 per cent of the guaranteed standard, the adjustment shall be proportional and shall be determined by the following formula: Heat unit adjustment.

$$\frac{\text{B. t. u. delivered coal ("dry-coal" basis)}}{\text{B. t. u. ("dry-coal" basis) specified in contract}} \times \text{bid price} = \text{price resulting for B. t. u. variation from the standard.}$$

The adjusted price shall be figured to the nearest tenth of a cent.

As an example, for coal delivered on a contract guaranteeing 14,000 British thermal units on a "dry-coal" basis at a bid price of $3 per ton, showing by calorific test results varying between 13,720 and 14,280 British thermal units, there would be no price adjustment. If, however, by way of further example the delivered coal shows by calorific test 14,350 British thermal units on a "dry-coal" basis, the price for this variation from the contract guaranty would be, by substitution in the formula:

$$\frac{14{,}350}{14{,}000} \times \$3 = \$3.075$$

(*b*) No adjustment in price shall be made for variations of 2 per cent or less below or above the guaranteed percentage of ash on the "dry-coal" basis. When the variation exceeds 2 per cent, the adjustment in price shall be determined as follows: Ash adjustment.

The difference between the ash content by analysis and the ash content guaranteed shall be divided by 2 and the quotient shall be multiplied by the bid price, and the result shall be added to or deducted from the B. t. u. adjusted price or the bid price, if there is no B. t. u. adjustment, according to whether the ash content by analysis is below or above the percentage guaranteed. The adjustment for ash content shall be figured to the nearest tenth of a cent.

As an example of the method of determining the adjustment in cents per ton for coal containing an ash content varying by more than 2 per cent from the standard, consider that coal for which the above-mentioned heat unit adjustment is to be made has been delivered on a contract guaranteeing 10 per cent ash, and shows by analysis an ash content of 7.50 per cent. The adjustment in price would be determined as follows:

The difference between 10 and 7.50, which is 2.50, would be divided by 2, and the quotient of 1.25 multiplied by $3, resulting in an adjust-

ment of 3.7 cents per ton, which in this case would be an addition. The price after adjustment for the variations in heating value and ash content would be $3.075 plus $0.037, or $3.112.

Moisture adjustment.

(c) The price shall be further adjusted for moisture content in excess of the amount guaranteed by the contractor, the deduction being determined by multiplying the price bid by the percentage of moisture in excess of the amount guaranteed. The deduction shall be figured to the nearest tenth of a cent.

As an example, consider that coal for which the above-mentioned heat unit and ash adjustments are to be made, and as having been delivered on a contract guaranteeing 3 per cent moisture, and that the coal shows by analysis 4.50 per cent moisture; then the bid price would be multiplied by 1.50 (representing excess moisture), giving 4.5 cents as the deduction per ton. The price to be paid per ton for the coal would then be $3.112, less $0.045, or $3.067.

Partial payment.

33. If coal on visual inspection by the Government inspector appears to be acceptable coal, the Government shall have the right, immediately on the completion of an order, to make payment on 90 per cent of the amount of the bill, based on the tonnage delivered and the bid price per ton. The 10 per cent withheld is to cover any deduction on account of the delivery of coal that on analysis and test is subject to an adjustment in price. If the 10 per cent withheld should not be sufficient to cover the deduction, then the amount due the Government may be taken from any money thereafter to become due to the contractor, or may be collected from the sureties. Because of the distance of the point of delivery from the laboratory, requiring several days for the transmittal of samples and the return of analytical report, because of loss of the original sample, necessitating the forwarding of the reserve sample, or for any other reason that would result in delayed payment, should such be withheld until receipt of analytical report, the Government may, as circumstances in its opinion warrant, exercise the foregoing right.

IX. ANTHRACITE COAL—DOMESTIC SIZES.

DESCRIPTION OF COAL DESIRED.

Character and quality.

34. The coal must be best quality, fresh-mined, anthracite, and it must be well screened, practically free from dirt, must not contain undue percentages of moisture, slate, or bone, or of coal of smaller sizes, and must equal in quality and preparation the best anthracite coal produced.

Information to be supplied by bidder.

35. The bidder shall be required to give the trade name of the coal offered, the name or other designation of coal bed or beds, the name of mine or mines producing the coal, location of mine or mines (town, county, and State), the name and address of the operator of mine or mines, and the railroad upon which the mine or mines are located, this information to be given in spaces provided hereinafter.

AWARD.

Considerations.

36. In determining the award of the contract, consideration shall be given to the results obtained with coals furnished on previous Government contracts by the respective bidders, as well as to the price per ton.

CAUSES FOR REJECTION.

Unsatisfactory coal.

37. If the percentage of bone, dirt, slate, or smaller sizes in a delivery exceeds the percentage required by the best preparation, or if the given coal fails to give satisfactory results because of excessive clinkering or excessive ash-pit refuse, it shall be subject to rejection, and payment may not be made for the remaining coal, and the Government shall have the right to cause the contractor to remove such coal at no cost to the Government. The Government may then purchase coal in the open market and make charge against the contractor for the excess in cost of coal so purchased.

Ash deductions.

38. If it is impracticable for the Government to cause the contractor to remove coal that produces excessive ash-pit refuse, samples may be taken during the consumption of such coal, provided not more than 50 per cent of the delivery had been consumed, and if on analysis the ash content on the "dry-coal" basis is equal to or greater than the following percentages for the respective sizes of coal, ten (10) per cent of the price of the delivery in question shall be deducted from any money due or that may thereafter be due the contractor:

Size of coal.	Ash in "dry coal," per cent.
Furnace	14
Egg	15
Stove	16
Chestnut	18

Unacceptable coal.

39. The Government inspector will not accept coal if, in his opinion, on visual inspection, it is subject to rejection, or if it contains an undue percentage of moisture, and he shall have the right to refuse to accept coal from a source other than that specified by the bidder, unless the contractor shall have received permission from the Government to substitute said coal.

Cancellation of contract.

40. If the contractor furnishes coal in three consecutive deliveries, or in case 20 per cent of the amount of the coal delivered to any date during the life of the contract is, in the opinion of the Government, subject to rejection, then the contract may, at the option of the Government, be terminated by written notice to the contractor to that effect.

PRICE AND PAYMENT.

41. Payment shall be made within thirty (30) days after the completion of an order and shall be based on the contract price, provided the coal is not subject to rejection.

X. INFORMATION TO BE SUPPLIED BY BIDDERS.

42. The following spaces should be filled in by the bidder for each bid, for if the information called for is not supplied, the proposal may be regarded as informal.

(Bidders are cautioned against specifying higher standards than can be maintained, for to do so may result in the bid being rejected, or may result in rejection of delivered coal or cancellation of the contract and the Government purchasing coal in the open market and charging against the contractor the difference in cost. See paragraphs 8, 29, 30, 31.)

.....

(To be signed by office issuing proposals.

.....

The undersigned agree.. to furnish to the ....., the coal described below, in tons of 2,000 pounds each, and in quantity as may be required during the fiscal year ending June 30, 191.., in accordance with the foregoing specifications; the coal to be delivered in such quantities and at such times as the Government may direct.

(*a*) Kind and size of coal.....
(*b*) Commercial name of coal.....
(*c*) Name of mine or mines.....
(*d*) Location of mine or mines (town, county, and State).....
.....
(*e*) Name or other designation of coal bed or beds.....
.....
(*f*) Railroad on which mine or mines are located.....
.....
(*g*) Name of operator of mine or mines.....
(*h*) Percentage of moisture in coal "as received".....
(*i*) Percentage of ash in "dry coal".....
(*j*) Percentage of volatile matter in "dry coal".....
(*k*) Percentage of sulphur in "dry coal".....
(*l*) British thermal units per pound of "dry coal".....
(*m*) Additional description of coal deemed of importance by the bidder.....
.....
(*n*) Price per ton of 2,000 pounds for delivery (for bituminous coal and for pea and buckwheat sizes of anthracite this price is understood to be the bid price per ton, see paragraph 32 for method of determining price for delivered coal).....

NOTE.—The information called for under *h*, *i*, *j*, *k*, and *l* is not required for bids on the domestic sizes of anthracite coal; that is, furnace, egg, stove, and chestnut.

The undersigned ha.. read the specifications and proposals and agree.. to comply therewith in every particular.

.....
Signature of each member of the firm and firm name. If a corporation, its name and signature of the officer authorized to sign for the corporation, together with a copy, under seal of his authority, to sign; also the name of the State in which incorporated. .....
.....
.....

Doing business under the firm name of.....
Place of business.....
Date.....

NOTE.—Owing to the difficulty in deciphering signatures, a typewritten copy of same should be attached.

APPENDIX A.

METHOD OF SAMPLING COAL DELIVERIES.

(To be attached to and to become a part of the Specifications and Proposals issued by the Office of the ....., for the purchase of coal for the fiscal year commencing July 1, 191.., and ending June 30, 191...)

NOTE.—As payment for bituminous and the steam sizes of anthracite coal is to be based upon the quality as shown by analyses of representative samples, it is imperative that every sample be collected and prepared carefully and conscientiously and in strict accordance with the method agreed upon herein, for if the sampling is improperly done, a determined price based on the analysis will be in error and it may be impossible or impracticable to take another sample; but if an analysis is in error, another analysis can easily be made of the original sample.

Gross samples of the quantities designated herein must be taken whether the delivery consists of a few tons or several hundred tons, because of the following cardinal principle in sampling coal that must be recognized and understood; that is, the effect of the chance inclusion or exclusion of too many or too few pieces of slate, or other impurities in what, or from what, would otherwise have been a representative sample will cause the analysis to be in error accordingly, regardless of the tonnage sampled. For example, the chance inclusion or exclusion of 10 pounds too much or too little of impurities in or from an otherwise representative sample of 100 pounds would cause the analysis to show an error in ash content and heating value of approximately 10 per cent, whereas for a 1,000-pound sample, the effect would be approximately only 1 per cent, the effect being the same whether the sample is collected from a 1-ton lot or from a lot consisting of several hundred tons.

Time of sampling.

1. The coal shall be sampled when it is being loaded into or unloaded from railroad cars, ships, barges, or wagons, or when discharged from supply bins, or from industrial railway cars, or grab buckets, or from the coal-conveying equipment, as the case may be and as may be mutually agreed upon. If the coal is crushed as received, samples usually can be taken advantageously after the coal has passed through the crusher. Samples collected from the surface of coal in piles or bins, or in cars, ships, or barges, are generally unreliable.

Size of increments.

2. To collect samples, a shovel or specially designed tool or mechanical means shall be used for taking equal portions or increments. For slack or small sizes of anthracite, increments as small as 5 to 10 pounds may be taken, but for run-of-mine or lump coal the increments should be at least 10 to 30 pounds.

Collection of gross sample.

3. The increments shall be regularly and systematically collected, so that the entire quantity of coal sampled will be represented proportionately in the gross sample, and with such frequency that a gross sample of the required amount shall be collected. The standard gross sample shall not be less than 1,000 pounds, except that for slack coal and small sizes of anthracite in which the impurities do not exist in abnormal quantities or in pieces larger than ¼ inch, a gross sample of approximately 500 pounds shall be considered sufficient. If the coal contains an unusual amount of impurities, such as slate, and if the pieces of such impurities are very large, a gross sample of 1,500 pounds or more shall be collected. The gross sample should contain the same proportion of lump coal, fine coal, and impurities as is contained in

the coal sampled. When coal is extremely lumpy it is best to break a proportional amount of the lumps before taking the various increments of a sample. Provision should be made for the preservation of the integrity of the sample.

Quantity represented.

4. A gross sample shall be taken for each 500 tons or less, or in case of larger tonnages for such quantities as may be agreed upon.

Preparation.

5. After the gross sample has been collected, it shall be systematically crushed, mixed, and reduced in quantity to convenient size for transmittal to the laboratory. The sample may be crushed by hand or by any mechanical means, but under such conditions as shall prevent loss or the accidental admixture of foreign matter. Samples of the quantities indicated in Table 1 following shall be so crushed that no pieces of coal and impurities will be not greater in any dimension, as judged by the eye, than specified for the sample before division into two approximately equal parts.

TABLE 1.—*Largest sizes of coal and impurities allowable in samples ranging from 1,000 to 30 pounds in weight.*

Weight of sample to be divided, pounds.	Largest size of coal and impurities allowable in sample before division.
1,000 or more	1 inch.
500	¾ inch.
250	½ inch.
125	⅜ inch.
60	¼ inch.
30	$\frac{3}{16}$ inch, or 4-mesh screen.

The method of reducing by hand the quantity of coal in a gross sample shall be carried out as prescribed below, even should the initial size of the coal and impurities be less than Table 1.

Hand preparation.

6. The progressive reduction in the weight of the sample to the quantities indicated in Table 1 shall be done by the following methods, which are shown in the accompanying illustration (Pl. V):

Mixing and reduction by discarding alternate shovelfuls.

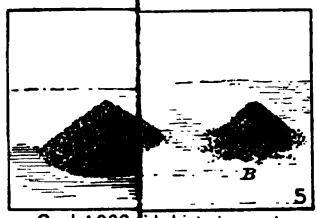
(*a*) The alternate-shovel method of reducing the gross sample shall be repeated until the sample is reduced to approximately 250 pounds; and care shall be observed before each reduction in quantity that the sample has been crushed to the fineness prescribed in Table 1.

The crushed coal shall be shoveled into a conical pile (figs. 2 and 7) by depositing each shovelful of coal on top of the preceding one, and then formed into a long pile in the following manner:

The sampler shall take a shovelful of coal from the conical pile and spread it out in a straight line (figs. 3, *A*, and 8, *A*) having a width equal to the width of the shovel and a length of 5 to 10 feet. His next shovelful shall be spread directly over the top of the first shovelful, but in the opposite direction, and so on back and forth, the pile being occasionally flattened until all the coal has been formed into one long pile (figs. 8, *B*, and 8, *B*). The sampler shall then discard half of this pile, proceeding as follows:

Beginning on one side of the pile, at either end, and shoveling from the bottom of the pile, the sampler shall take one shovelful (shovelful No. 1, figs. 4 and 9) and set it aside; advancing along the side of the pile a distance equal to the width of the shovel, he shall take a second shoveful (shovelful No. 2, figs. 4 and 9) and discard it; again advancing

First stage in the preparation of 1,000-pound sample.



Crush 1,000- ided into two parts; hard, clean rve; B—reject

NOTE

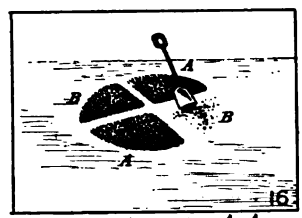
SELECT A HARD, CLEAN SURFACE, FREE OF CRACKS AND PROTECTED FROM RAIN, SNOW, WIND, AND BEATING SUN. DO NOT LET CINDERS, SAND, CHIPPINGS FROM FLOOR, OR ANY OTHER FOREIGN MATTER GET INTO THE SAMPLE. PROTECT SAMPLE FROM LOSS OR GAIN IN MOISTURE

Second stage.

Crush 500 ided into two parts; (fig. 5, rve; B—reject

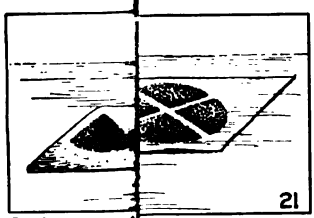
Third stage.

Crush 250 ided into quarters (fig. 10, A

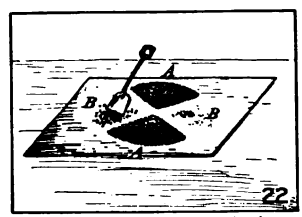


Retain opposite quarters A, A. Reject quarters B, B

Fourth stage.

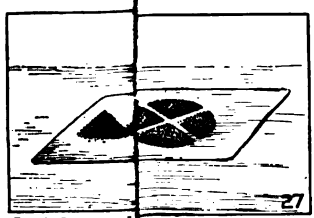


Crush 125-pound ided into quarters on blan

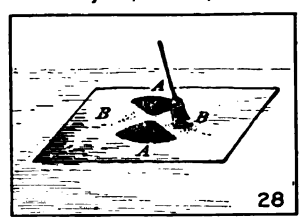


Retain opposite quarters A, A. Reject quarters B, B

Fifth stage.

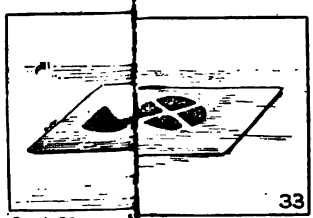


Crush 60-pound ided into quarters to

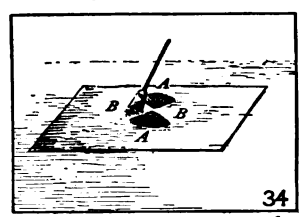


Retain opposite quarters A, A. Reject quarters B, B

Sixth stage.



Crush 30-pound ided into quarters to 3/16"



Fill two 5-pound sample containers from A, A, one for laboratory, one for reserve

METHOD FEET, BROOM, AND RAKE. THE COAL IS RAKED TER SAMPLE IS HALVED OR QUARTERED.

in the same direction one shovel width, he shall take a third shovelful (shovelful No. 3, figs. 4 and 9) and add it to the first. Shovelful No. 4 (figs. 4 and 9) is to be taken in a like manner and discarded, the fifth shovelful (No. 5, figs. 4 and 9) retained, and so on, the sampler advancing always in the same direction around the pile, so that its size will be gradually reduced in a uniform manner. When the pile is removed, about half of the original quantity of coal should be contained in the new pile formed by the alternate shovelfuls which have been retained (figs. 5, *A*, and 10, *A*, show the retained halves, and 5, *B*, and 10, *B*, the rejected halves).

Mixing and reduction by quartering.

(*b*) After the gross sample has been reduced by the above method to approximately 250 pounds, further reduction in quantity shall be by the quartering method. Before each quartering, the sample shall be crushed to the fineness prescribed in Table 1.

Quantities of 125 to 250 pounds shall be thoroughly mixed by coning and reconing (figs. 12 and 13); quantities less than 125 pounds shall be placed on a suitable cloth, measuring about 6 by 8 feet, mixed by raising first one end of the cloth and then the other (figs. 18, 24, and 30), so as to roll the coal back and forth, and after being thoroughly mixed shall be formed into a conical pile by gathering together the four corners of the cloth (figs. 19, 25, and 31). The quartering of the conical pile shall be done as follows:

The cone shall be flattened, its apex being pressed vertically down with a shovel or board, so that after the pile has been quartered each quarter will contain the material originally in it. The flattened mass, which shall be of uniform thickness and diameter, shall then be marked into quarters (figs. 14, 20, 26, and 32) by two lines that intersect at right angles directly under a point corresponding to the apex of the original cone. The diagonally opposite quarters (*B*, *B* in figs. 16, 22, 28, and 34) shall then be shoveled away and discarded and the space that they occupied brushed clean. The coal remaining shall be successively crushed, mixed, coned, and quartered until two opposite quarters shall equal approximately 10 pounds of $\frac{1}{16}$-inch or 4-mesh size. This 10-pound quantity shall be divided into two equal parts and each part shall be placed in a container suitable for transportation and shall bear an unbroken seal. One of the samples shall be forwarded by the officer in charge to the Bureau of Mines, Department of the Interior, for analysis, and the other shall be held in reserve by the officer in charge. Should the sample forwarded be lost or damaged in transit, then the reserve sample shall be forwarded.

Mechanical preparation.

7. Only such mechanical means as will give equally representative samples shall be used in substitution for the hand method of preparation herein specified.

Extended deliveries.

8. For convenience, or if the accumulation of a sample would extend over any considerable period of time, the several quantities that would otherwise be combined to make up the gross sample may be worked down as collected and reduced to samples of a size suitable for transmittal to the laboratory, and these fractional samples may be analyzed and the several analyses averaged, or the several samples may later be mixed at the place of sampling or in the laboratory and reduced to one sample, one analysis being made. In the averaging of analyses or in the mixing of the several samples, weights shall be used proportionate to the tonnages which the fractional samples represent.

Special moisture sample.

9. In the reduction of the gross sample to the sample for transmittal to the laboratory, the gross sample may unavoidably lose moisture. To determine the moisture content in the coal delivered, a separate special moisture sample may be taken. This special moisture sample shall be taken so as to represent the coal with respect to the moisture contained at the time of weighing.

Collection of moisture sample.

10. The special moisture sample shall weigh approximately 100 pounds, and shall be accumulated by placing in a waterproof receptacle with a tight-fitting and waterproof lid small equal parts of the freshly taken increments of the gross sample, or they may be collected separately and independently of the gross sample. The accumulated moisture sample shall be rapidly crushed and reduced mechanically or by hand to about a 5-pound quantity, which shall be immediately placed in a container and sealed air-tight and forwarded to the laboratory. If prepared by hand, it shall be rapidly crushed so that no pieces of coal or impurities are larger than one-half inch, and it shall be rapidly reduced by the quartering method on a cloth to the 5-pound quantity.

Moisture samples discretionary.

11. The collection of special moisture samples shall be discretionary with the Government. If special moisture samples are not taken, the moisture determined for the gross sample shall govern, provided the gross sample shall be taken so as to represent the coal with respect to the moisture contained at the time of weighing, otherwise the moisture determination shall be waived.

Moisture sample may represent any part of delivery.

12. A special moisture sample may be taken from any one railroad car or cars, or from a part of a delivery, if, in the opinion of the Government, said car or cars, or said part of a delivery contains moisture in excess of the amount guaranteed by the contractor, and should the moisture content of this special sample be in excess of the moisture content guaranteed by the contractor, then the Government shall have the right to make a deduction in price in accordance with paragraph 32 (*c*) under "Price and Payment," for the car or cars, or the part of the delivery sampled, and this correction shall in no wise affect the moisture correction for other railroad cars or parts of the delivery that may be sampled, or the correction that shall apply for variations of ash and heating value as determined for the delivery or order. The special moisture sample shall be used for no other purpose than for determining moisture content, and the moisture content so determined shall be considered as final.

Sampling of 50 tons or less discretionary.

13. When orders are issued for 50 tons or less, sampling shall be discretionary with the Government; and if samples are not taken, the bid price per ton shall be paid.

PUBLICATIONS ON FUEL TECHNOLOGY.

A limited supply of the following publications of the Bureau of Mines is temporarily available for free distribution. Requests for all publications can not be granted, and applicants should limit their selection to publications that may be of especial interest to them. Requests for publications should be addressed to the Director, Bureau of Mines, Washington, D. C.

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STRUCTURE IN PALEOZOIC BITUMINOUS COALS

BY

REINHARDT THIESSEN

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geologists known the true nature of coal they could not have made this mistake nor many others made in the past.

To fill in a few of these gaps and to clarify some of the existing confusion is the aim of this paper.

The immediate cause that led the author to investigate further the composition of coal and the origin and structure of its constituents was that when an attempt was made to discover the meaning of the coking and noncoking properties of coal a more exact knowledge of the nature of coal was required than was then available.

THE COALS STUDIED.

The coals that formed the basis of the study described in this bulletin were selected from the following localities: From the Pittsburgh bed at the Oak mine, a short distance south of Pittsburgh, Pa., at the experimental mine of the Bureau of Mines near Bruceton, Pa., at the Keystone mine, Madison, Pa., and several samples from unknown places collected in Pittsburgh from coal for domestic purposes; from the Jagger bed, at the No. 11 mine of the Galloway Coal Co., Carbon Hill, Walker County, Ala.; from the Black Creek bed at the Sipsey mine, Maryland Coal & Coke Co., Sipsey, Walker County, Ala.; from Consolidated Coal Co. mine No. 18, Buxton, Monroe County, Iowa; from Bed No. 5, at the No. 82 mine of the Vandalia Coal Co., near Terre Haute, Vigo County, Ind.; from Bed No. 6 (Herrin coal), at the mine of the Hart-Williams Coal Co., near Benton, the mine of the Benton Coal Co. near Benton, the Zeigler mine of the Bell and Zoller Coal Co. at Zeigler, the north mine of the Franklin Coal & Coke Co., at Royalton, and a mine near Sesser, these five mines all in Franklin County, Ill.; and from Bed No. 14 in the "barren measures," McLeansboro formation, near Shelbyville, Shelby County, Ill. Comparisons were made with coals from other localities and other parts of the world, as from China, Japan, New South Wales, and England.

The coal samples were collected according to the standard method of sampling, except the coals from the Oak mine in the Pittsburgh bed, where a series at intervals of a foot were collected, the coal from the Royalton mine, samples of which were collected from near the top, the middle, and just below the carbonaceous shale band, and the samples from the Buxton mine, which were collected in a series from top to bottom.

HISTORICAL REVIEW.

THE WOODY STRUCTURE IN COAL, AND THE MEANING OF THE ALTERNATING DULL AND BRIGHT LAMINÆ.

The knowledge of the woody structure in coal has been obtained largely from fractures horizontal to the bedding planes, and to some

extent from the so-called impressions, but mainly from the charcoal present in almost every coal. Very little structure seems to have been observed in the compact coal; what was at one time supposed to be the structure of wood later proved to be not that of wood at all but thin flat strips derived from woody tissues. The latest verdict even goes so far as to say that no woody structure has been preserved in coal except in the charcoal.

Since the earliest investigations all ordinary coals were known to contain compact coal and charcoal, also called "mother of coal," compact coal forming by far the larger proportion. The compact coal in turn is composed of two kinds, a bright and a dull coal. The dull coal has been called by various authors, "dull coal," "matt coal," "canelloid coal," and "sapanthrakon," while the bright bands have been called, "bright coal," "glanz coal," "humus coal," "jet coal," "carbohumin," and "hydrocarbon." But the true significance of these two kinds has never been definitely explained. In order to discuss clearly the alternating bright and dull bands and the woody structure, the results and interpretations of investigations since the time that a minute examination of coal was begun are briefly recounted.

HENRY WITHAM, 1831–1832.

Witham,[a] who was the first to make thin coal sections, saw and illustrated a confused cellular tissue that seemed to him to be that of vascular plants. As he found and illustrated the same bodies in a cannel coal, evidently they were not cell structures of vascular plants, but cross sections of spores. Hutton,[b] who examined coals from Newcastle and the surrounding territories in England, thought that the ordinary splint or slate coal was composed of cannel coal and coking coal arranged in thin alternating layers because of the remarkable bodies seen in the sections made by Witham. The layers of cannel coal he found to be composed largely of light wine-colored cells, and few of them could be found in the layers of the coking coal. In the best portions of the coal, the "most homogeneous and the most crystalline" parts in which the plant texture had been obliterated entirely, these cells could not be found at all. The coking coal was the best and the

[a] Witham, Henry, On the general results of botanical investigation concerning the character of the ancient flora which by its composition has furnished the material of coal seams: Rept. 1st and 2d meetings British Ass'n Adv. Sci., 1831 and 1832, p. 78; On fossil vegetation: Rept. 1st and 2d meetings British Ass'n Adv. Sci., 1831 and 1832, p. 578. Bennie, James, and Kidston, Robert, On the occurrence of spores in the Carboniferous formation of Scotland; Proc. Roy. Phys. Soc. Edinburgh, vol. 9, 1885–1888, pp. 82–117.

[b] Hutton, W., Observations on coal. London and Edinburgh Mag. and Jour. of Science, vol. 2, 1883, pp. 302–304.

largest proportion of the coal. In all of the varieties of coals he observed some plant structure. It is quite evident from what is now known of coal, that the layers called coking coal by Hutton were the anthraxylon components, and the layers of cannel coals were the attritus in which the anthraxylon components were embedded, exactly as in the coals of this country.

FRIEDERICK LINK, 1838.

Link[a] could not find any woody structure in the coals except in the charcoal, or mother of coal. He believes that what Hutton saw was not the structure of wood but something else, otherwise he would have spoken of wood fibers and not confined himself entirely to cells.

H. R. GÖPPERT, 1840–1848.

All the observations and identifications of plants made in the list of Göppert's[b] memorable study was of horizontal cleavage fracture, and particularly of the charcoal. He almost always speaks of impressions, and mentions the stems, "or, more properly, their barks," lying flat one upon another without the inner parenchyma. The latter sometimes was preserved also and converted into coal—often so well preserved that the cells could still be recognized under the microscope. As Göppert never mentioned thin sections his microscopic examinations were presumably of small fragments of coal, and most likely of the horizontal faces of very thin chips or splinters that he frequently mentions.

JOHN QUECKETT, 1853.

Queckett,[c] in comparing cannel coal with the Torbane Hill mineral, points out the woody structure in cannel coal in which cells and fibers may be recognized distinctly. But from his illustrations, which probably are very good representations of what he saw, his "cells" were cross-sections of spores and his "fibers" were thin layers of woody coal or the anthraxylon components.

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[a] Link, Friederick, Ueber den Ursprung der Steinkohlen und Braunkohlen nach mikroskopischen Untersuchungen: Abhandl. K. Akad. Wiss. Berlin, 1838, pp. 33–44.

[b] Göpperl, H. R., Über die Verbreitung der fossilen Gewächse in der Steinkohlenformation: Schlesische Gesell. Übersicht, 1840, pp. 74–77; Über die Holzarten in den braunkohlenartigen Ablagerungen: Kartstens Archiv., Bd. 18, 1844, pp. 527–529; Uber das verhältniss der Boghead Parrot Cannelcoal zur Steinkohle: Dingl. poly. Jour., Bd. 145, 1857, pp. 212–217; Abhandlung. eingesandt als Antwort auf die Preisfrage—"Man suche durch genaue Untersuchungen darzuthun, ob die Steinkohlenlager aus Pflanzen entstanden sein. welche an den Stellen, wo jene gefunden werden, wuchsen; oder ob diese Pflanzen an anderen Orten lebten, und nach den Stellen, wo sich die Steinkohlenlager befinden hingefürt wurden": Nat. Verh. Monatschr., Bd., 4, 1848, pp. 1-298.

[c] Queckett, John, On the minute structure of a peculiar combustible mineral from the coal measures of Torbane Hill, near Bathgate, Linlithgowshire, known in commerce as Boghead cannel coal: Trans. Micros. Soc. London, vol. 2, 1853, pp. 34–66.

JOHN BALFOUR, 1854.

Balfour[a] calls attention to the same error, and calls these same objects "spaces and cavities."

J. W. DAWSON, 1859–1866.

Dawson[b] appears to be the first to recognize that coal is composed of compact coal and mineral charcoal, and that the compact coal, by far the larger proportion of the mass, "consists of lustrous concoidal cherry (or pitch coal), or of less lustrous slate coal with flat fracture, or of coal containing much earthy matter arranged in thin interrupted laminæ. The vegetable matter to which it owes its origin has been transformed, through a process of subaqueous bituminous putrefaction, into a nearly homogeneous mass in which traces of structure and of flattened plants composing it are still recognizable. Dawson's studies convinced him that the "bright coal" had its origin in the barks of Sigillaria and allied plants, the "dull coal" came from herbaceous plants and molds, and the wood and bark tissues yielded mineral charcoal.

On a close analysis he found that the layers or laminæ of the cherry coal or pitch coal and those of the finer varieties of slate coal showed on the surfaces outlines of flattened trunks, but that the laminæ of the coarse coal seemed to consist of numerous sublaminæ of disintegrated vegetable matter mixed with mud. Evidently he viewed the coal on the surfaces only and not through thin sections, although he used thin sections. The difficulty probably was that his sections were not thin enough to permit him to recognize the cell structure.

THOMAS H. HUXLEY, 1870.

Huxley[c] saw wood structure in the charcoal only and none in the coal proper, which, he observes, constituted the larger proportion of all bituminous coal, and was chiefly composed of "saccular" matter. Occasionally he observed remnants of bark, but he believed the wood of the plants had decayed, and that none of it was left; the woody structures observed, except in the charcoal, were only the imprints of stems.

W. C. WILLIAMSON, 1881.

Williamson,[d] like Huxley and Dawson, recognized two kinds of coal—charcoal, and the more bituminous, or compact coal. Woody

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[a] Balfour, J. H., On certain vegetable organisms found in coal from Fordel: Trans. Roy. Soc. Edinburgh, vol. 21, 1854, pp. 187–193.

[b] Dawson, J. W., On the vegetable structure in coal: Quart. Jour. Geol. Soc. London, vol. 15, 1859, pp. 626–641; on the condition of the deposition of coal, more especially as illustrated by the coal formation of Nova Scotia and New Brunswick: Quart. Jour. Geol. Soc. London, vol. 22, 1866, pp. 95–169.

[c] Huxley, T. H., On the formation of coal: Contemporary Review, vol. 15, 1870, pp. 618–628.

[d] Williamson, W. C., Preliminary remarks on the microscopic structure of coal: Rep. British Ass'n. Adv. Sci., 1881, pp. 625–626.

structure he observed in the charcoal only. The compact coal he concluded to be of an entirely different nature, and to consist of two components—(*a*) spores embedded in (*b*) a general matrix that he calls a brown plasm; the origin of this plasm he believed to be decayed vegetation, but he left the question open.

G. W. VON GUEMBEL, 1883.

Von Guembel[a] is generally conceded to have furnished the most comprehensive and the most reliable account of the structure of coal. Up to his time the knowledge of coal was mainly obtained through the study of its cleavage surfaces, which have been interpreted correctly by few investigators. Thin sections were difficult to make, and the appliances needed for observing them were inadequate. Guembel fortunately adapted a process employing a maceration reagent which was used by Schulze[b] to purify cellulose, and later was used in the endeavor to determine cellulose in coal. By means of this reagent Guembel macerated the coals to various degrees, and watched the process of dissolution under the microscope, and in that way he procured more accurate information concerning coal than anyone had obtained before. He was a careful and conscientious investigator and gave his results to the public only when he was sure of his ground, or, at the most, he gave suggestions as to the possible conclusions, and in that way he presented the probability of important facts, the evidence for which he believed to be inconclusive.

Guembel agrees with the general observation, so strongly emphasized by Mück and Grand 'Eury at the time, that coal is composed mainly of thin layers of alternating "glanz" and "dull coal," often with interlayers of charcoal in the form of scattered débris or of solid masses or strips. He thought that only a very few coal beds consisted predominantly of either "dull coal" or of "glanz coal," and that the main mass in some beds was formed of charcoal.

The "glanz" or "bright coal" he describes as consisting on the whole of an intensive brown mass, apparently without structure when seen in thin chips. When treated with the macerating reagent it revealed only very small traces of plant structure, but he recognized various plant tissues in it when he further treated it with alcohol and ammonia, or when he heated it with the macerating reagent. Parenchymatous cells, such as occur in the bark, were chiefly observed, also tissues similar to those of wood, parts of leaves revealed through the presence of cuticles, and circular, cuticular disks or spherical bodies, usually called spores. He rarely failed

[a] Von Guembel, C. W., Beiträge zur Kenntniss der Textur verhältnisse der Mineralkohlen: K.-b. Akad. Wiss. Munich, Sitzungsber. math.-phys. Klasse, Bd. 13, 1883, pp. 111–216.

[b] Schulze, Franz, Ueber das Vorkommen wohlerhaltenes Cellulose in Braunkohle und Steinkohle: Sitzungsber. K. preuss. Akad. Wiss. Berlin, 1855, pp. 676–678.

to recognize abundant plant structure, yet he says that he did not succeed in obtaining complete evidence that the whole mass of coal included distinguishable plant structures. He was almost convinced that often the plant substances have been so uniformly transformed into "glanz coal" that the difference between the tissues and the fillings of the interstices with "carbohumin" may be distinguished only through very careful treatment. He had, no doubt, according to observations made on dopplerite, perceived that true structureless substances form part of certain coal deposits.

The "dull coal" appeared to him to be composed almost entirely of fibrous cells, such as those from leaves of grasses, with parenchymatous tissue. a few spores, and a few scalariform vessels.

EDWARD WETHERED, 1885.

Wethered[a] also distinguished in the compact coal two kinds—a bright and a dull, alternating with each other. He found the "dull coal" contained numerous spores but the "bright coal" few or none. The "bright coal" consisted of a structureless dark-brown mass, which he believed was mainly composed of "hydrocarbon" and a very important component of coal. The so-called bituminous coals contained more of it than the others.

H. POTONIÉ, 1906–1910.

Potonié[b] distinguishes as regards origin and formation three kinds of coal: Sapropellic, humus, and liptobiolithic. The sapropellic coals are formed from true aquatic organisms, both plants and animals, through a process of putrefaction under exclusion of oxygen. When these are of Paleozoic age he calls them sapanthrakon and regards them as equivalent to the cannel coals. On account of their dull appearance he also calls them matt coals. The humus coals are formed primarily through a process of decay under partial exclusion of oxygen from true land plants preferring moist conditions. Under the microscope the humus coals show components derived from higher land plants and embedded in a flocculent, homogeneous groundmass. On account of their lustrous nature they are also called glanz coals. Liptobiolithic coals have been formed from land plants rich in resin, resin-waxes or waxes, which, on account of their resistant nature, were left behind when most of the cellulosic matter decayed.

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[a] Wethered, Edward, On the structure and origin of carboniferous coal seams: Trans. Roy. Micros. Soc., vol. 5, 1885, pp. 406–410.

[b] Potonié, H., Klassification und Terminologie der regenten brennbaren Biolithe and ihre Lagerstätten: Abhandl. K. geol. Landesantalt, Bd. 48, 1906; Die Enstehung der Steinkohle, und der Kanstobiolithe überhaupt, wie des Torfes, der Braunkohle, des Petroleums, u. s. w., 1910.

As all laminated coals are composed of alternating sheets of "matt coal" and "glanz coal," Potonié conceived them to be composed of alternating layers of sapropellic coals (matt coal, cannel coal) and humic coals (glanz coal), and the phenomenon to have been brought about under changing conditions during coal-forming periods; that is, during certain times, when the water was high, sapropellic (cannel coal) forming conditions prevailed, and at other times, when the water was relatively low, peat or humus was formed under merely moist conditions. Such conditions might alternate many times during the deposition of a coal seam. There was, so to speak, a struggle between high water and moist or swampy conditions, and a laminated coal was the result.

Potonié considered only the larger anthraxylon components alternating with the débris as they appear to do in small pieces of coal, but evidently he did not analyze the débris so as to become aware that it is also composed of alternating sheets of "matt coal" or the attritus, and "glanz coal." He thought that the layers of "glanz" or humus coals were composed of a general degradation of land plants and were in a homogeneous condition, similar to Wethered's "carbohydrate," and that they did not consist of separate and individual components that had been at one time pieces of stems or wood; that is, pieces of anthraxylon merely embedded in a débris, or general degradation of plants contemporaneously formed.

JAMES LOMAX, 1912.

Lomax,[a] after examining a series of coals, finds that they are not homogeneous, but contain well-defined structures, and most of them are decidedly laminated, consisting of alternating bands of bright and dull coals. The dull laminæ are composed of numerous megaspores embedded in a groundmass composed chiefly of microspores; the brighter laminæ are composed of microspores in a groundmass of the remains of leaves and other plant tissues highly compressed. Some coals have less spore matter and more bands with compressed leafy residue, with here and there woody tissues inclosed, often in the form of mother of coal; but the real nature of the bright coal he does not perceive. Lomax concludes that coals do not "contain so great a quantity of material derived from the vascular or woody parts of plants, such as stems and branches, etc., as some recent authors have led one to believe. In fact, there is little evidence that any great quantity of wood enters into their composition, and what there is occurs in the form of charcoal or mother of coal."

The coals examined, except those of the Trencherbone, cannel, and Silkstone Tops, he calls purely humic coals, mainly composed of

[a] Lomax, James, The microscopic examination of coal and its use in determining the inflammable constituents present therein: Trans. Inst. Min. Eng., vol. 42, 1912, pp. 2–21.

the droppings of trees and plants in the form of spores, fruits, leaves, twigs, and sometimes fragments of stems. The material in the brighest and hardest ones, he thinks, had been reduced to a pulpy state before carbonization.

SAMUEL GLOVER, 1912.

Glover,[a] who worked on Lomax's preparations, largely shares the views of Lomax. He observes a conspicuous absence of cellulosic or "actual vegetable" matter such as tree trunks, branches, twigs, and other woody tissues. The only remains of trunks found are those of erect stumps running upward through the coal seam, with occasional branches and pieces of bark near the top of the deposit. He concludes that the English coals investigated are the accumulations of leaf-moulds of a very luxuriant and dense vegetation.

DAVID WHITE AND REINHARDT THIESSEN, 1914.

White and Thiessen[b] seemingly were the first to interpret the alternating bright and dull laminæ in the few bituminous coals so far examined. They concur in the old-time observation that coal is composed of alternating bright and dull layers, but they go a step further by asserting that the dull layers are further sublaminated into "bright" and "dull" laminæ, the sublaminæ often being of microscopic thickness. The bright laminae represent components that were at one time parts of trunks of trees, stems, twigs, and branches, now much flattened and coalified. The dull laminæ are derived from more or less finely divided plant substances; the débris corresponds in every respect to the fine black matter, or fine mud in peat, and forms the groundmass in which the woody components are invariably embedded.

EDWARD C. JEFFREY, 1914–1915.

Jeffrey[c] also concurs with the general observation in recognizing three kinds of coals; charcoal, lignitoid (bright coal, glanz coal) and canneloid (dull coal, matt coal). In the ordinary bituminous coals these three kinds occur in alternating layers. Plant structure has survived only in the charcoal. The canneloid bands of the bituminous coals consist of a dark ground substance like that of the ordinary cannel coals, in which are embedded the remains of flattened spores. The "lignitoid" laminæ consist of highly modified wood, and are homogeneous, having entirely lost their original structure.

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[a] Glover, Samuel, Notes introductory to the study of coal sections under the microscope: Jour. Gaslighting, etc., vol. 20, 1912, pp. 737–739.

[b] White, David, and Thiessen, Reinhardt, Origin of coal, Bull. 38, Bureau of Mines, 1914, 390 pp.

[c] Jeffrey, Edward C., On the composition and qualities of coal. Econ. Geol., vol 9, 1914, pp. 730–742; The mode of origin of coal: Jour. Geol., vol. 23, 1915, pp. 218–270.

Of the 200 coals or more examined from the United States and many other coals from all over the world, Jeffrey finds none that show woody structure except in the charcoal. Although he concurs with the view that the bright laminæ in coal are derived from the woody parts of plants, he seems to have found no proof for this statement, and does not show the real nature of the laminæ.

GEORGE HICKLING, 1917.

Hickling[a] agrees with White and Thiessen in the interpretation of the "bright coal" and the "dull coal," in his paper on the micropetrology of coal. But he differs regarding the origin of certain essential components of coal, the relationship between the plant tissues, whose forms are visible under the microscope, and the actual coal substances that now composes the visible structures. He believes it presumptuous to assume that the substance, as well as the form, of the plant, is under observation, and presumptuous to believe that the portion of the coal in question represents the actual material of the original plant in a more or less altered condition. In regard to contents or "fillings" of some of the cells in some remaining fragments of tissues, Hickling believes that the substance filling these cells can have no connection with any substance that may have been present in the living cell itself. He believes that the plant fragments became saturated with liquid decomposition products of other vegetation, that they osmotically reached their present condition, and that subsequent physicochemical changes have solidified them. The cell walls themselves have doubtlessly been impregnated with the same material if not ultimately replaced by it. A considerable replacement of the walls must have taken place, and, therefore, only a small fraction of the mass represents the original cell fibers of the structures that are still visible.

METHODS OF EXAMINING SAMPLES.

PREPARATION OF THIN SECTIONS.

SELECTION OF THE SPECIMEN.

Examination of thin-ground sections under the microscope has proved the most successful and most satisfactory method. In such thin sections the coal is examined in its original chemical and physical condition and natural color. Nothing whatever has been changed except that the coal has been ground thin enough to be transparent. Sections have been prepared thin enough to permit photography through the microscope at a magnification as high as 2,000 di-

[a] Hickling, George, A contribution of the micropetrology of coal: Trans. Inst. Min. Eng., vol. 53, 1917, pp. 137–158; abstracted in Coll. Guard., vol. 113, 1917, pp. 141–443.

ameters. Some skill, experience, and patience, however, are required to prepare them.

A piece or block of coal with few cracks or checks was chosen for preparation; one without any checks is best, although this was not always possible to obtain.

PREPARATION OF THE PLANE SURFACE.

The block chosen was cut to a size convenient to handle, and one surface was ground to the size desired for the section. The larger the section the more difficult it is to grind, but the greater is its value. The most desirable size is about three-fourths of an inch long and one-half of an inch wide. The surface selected for the section was ground to a perfect plane. If it was to be a cross section, it was ground at right angles to the bedding planes; if it was to be a horizontal section it was ground as nearly horizontal as possible to the bedding planes. This plane surface was then polished to remove microscopic scratches. It has not been possible to obtain a surface entirely free from such scratches, nor is it advisable to do so, as the time spent on polishing is worth more than the benefit derived from a scratchless surface.

The first rough grinding was done with fine powdered carborundum paste on a wheel of carborundum of fine texture. When the blocks had been cut down to the plane desired, the grinding was continued on the same carborundum wheel without the abrasive, but with a fine stream of water playing on the plane until the surface was quite smooth. Most bituminous coals are not damaged by water if soaked for a few minute only. Water will not adhere readily to a newly cut surface because of the differences in surface tension. The surface was then smoothed by hand on a very fine hone on which a fine stream of water played. From time to time the hone was rubbed down with a second hone, or "rubber' furnished with "bluestone" hones, as when a carpenter makes a lather, in order to remove fine particles of coal that are apt to stick or gum to the hone. This last process polished the surface enough if carefully done; if further polishing was found necessary the surface was rubbed carefully on a leather block strop.

When the surface, which must be plane, was properly polished, the block was cemented on an object slide, the polished surface being toward the slide.

THE CEMENT.

The cement used to cement the specimens to the object slide was made of three parts of Canada balsam and two parts of marine glue, heated together in a drying oven at a temperature of about 105° C. The proper consistence was determined by trial. It should be such that the cement when cooled will harden and yet not be brittle. The

success of the process depends to a great degree on proper consistence of the cement. When a portion of cement had been prepared it was put away, protected from dust and heat, for future use.

WATERPROOFING THE SPECIMENS.

Before the block was cemented to the object slide the prepared surface was waterproofed. Unless this was done the section, when it became quite thin during the next step of grinding, absorbed enough water to cause it to swell, buckle, and finally peel off.

Waterproofing was done by soaking the prepared surface for a few minutes in paraffin after both the specimen and the paraffin had been heated to about 105° C.

CEMENTING THE BLOCK ON THE SLIDE.

All superfluous paraffin was then wiped off the prepared surface. The object slide and the prepared surface with a bit of the cement on each were left in the drying oven at a temperature of 105° C. until the cement was molten and contained no gas bubbles. The coal was pressed with a clamp onto the warmed slide as close to it as possible, taking care that no air bubbles got between or remained between the sample and the slide, and that the clamp was screwed down so as not to bend the block of coal or the slide and spoil the specimen. It was then left to cool slowly to room temperature.

THE SECOND GRINDING.

After the preparation had cooled the block of coal was ground down roughly on the carborundum wheel with the aid of the carborundum powder and water. Then without the powder and after every particle of the carborundum powder had been rinsed off the section was carefully ground down further on the carborundum wheel as thin as could be done without endangering it.

THE FINAL GRINDING.

The section was finally ground down by hand on the fine hone and in the same manner as in the first step. Great care had to be taken as the section approached the required thinness. To keep the grinding even the section was examined from time to time under the microscope.

In cold weather the water used in the grinding had to be warmed to room temperature or slightly higher.

THE PREPARATION OF POLISHED SURFACES FOR OBLIQUE ILLUMINATION.

The surfaces for this method of examination were prepared exactly as the plane surface for thin section, except for the final finish.

After the surface had been smoothed enough in the wet way on the hone, both hone and specimen were carefully dried. The grinding was then continued with long even strokes in one direction only until the surface was sufficiently polished. Care had to be taken to keep all grit and dirt from coal and hone, in order to prevent scratching. This process gives the components in the coal clean sharply cut edges or cross sections. The preparation could not be further polished in any way without smearing the various components over the surface, making the surface useless for photography and less valuable for direct microscopic examination.

The specimens thus prepared for examination and photography with oblique illumination may well be used later for preparing thin sections, provided they have not been spoiled by too strong a light, or rather by too high a temperature. Strong light is necessary in making a photomicrograph from such a surface, and the heat accompanying it often cracks the coal and renders the surface uneven and useless for a thin section.

ORIGIN OF PEAT.

That coal has been formed from plants is no longer doubted by anyone who is familiar with the subject. But the exact manner in which plant substances were transformed into coal is still under discussion. The writer is thoroughly convinced, by his own studies and the studies of other investigators, that coals had their origin in peat beds.

The origin of peat must be analogous to that of coal, because its components are in every respect analogous to those of coal. A knowledge of peat, therefore, will help to explain much in coal that otherwise could not be clearly understood or not understood at all.

PEAT DEPOSITS.

OCCURRENCE.

A peat bog may be known as a tamarack swamp, cedar swamp, a black-ash swamp, a cypress swamp, a marsh, or a slough, according to the kinds of plants that form the main vegetation of the bog. Such swamps are found all over the United States, but are particularly abundant because of the many lakes and ponds formed there at the retreat of the great continental ice sheet in the northern tier of States east of the Red River Valley. Some swamps are of considerable size and have become well known, like the Dismal Swamp of Virginia and North Carolina. Many of these swamps are filled with a dense growth of trees or with trees and underbrush; some are covered with a dense growth of shrubbery only, others have a dense growth of sedges, grasses, bullrushes, and other herbaceous plants. In some there is an open area of water near the center.

Many such swamps have been reclaimed; despoiled of all original plant growth, they serve as fertile pastures or cultivated lands. Those that relate to our subject are those that are overgrown densely with trees and shrubbery, with coniferous trees, such as the white cedar (*Thuya occidentalis*), the black spruce (*Picea mariana*), and the tamarack (*Larix laricina*) predominating. Some of these swamps are almost impenetrable because of the tangle of fallen and reclining trees intergrown with shrubbery of many kinds. A general idea may be obtained from the photographs shown in Plates I–III, taken in different peat swamps of Wisconsin. These show the general density of the growth, the reclining position of many of the trees, and the contour of the substratum. Some trees are down, some are already partly covered, and others, as indicated by humps, are entirely covered by débris. On account of their uniform hold in the loose soil, many of the trees in the reclining position gradually come down further and further year by year, until they lie prostrate on the ground. In this position they may die and gradually rot or continue to live for an indefinite time; in either case their trunks become covered by the general débris in the years that follow. Other trees are overturned rapidly by storms and heavy snowfalls. To the fallen trunks and limbs are added year by year limbs, twigs, leaves, fruits, spores, and pollens.

DISINTEGRATION OF PLANT SUBSTANCES.

As long as this mass of plant substances is exposed to the air in moist surroundings much of it rots with comparative rapidity and much of the woody material and leaves and many of the herbaceous plants disintegrate and form a general débris and attritus. When covered by the wet deposits of subsequent years decay takes place slowly and further disintegration practically ceases.

The greatest and the quickest transformation of vegetable substances into peat is on the surface where there is free access of oxygen and exposure to the weather. Initial decay, particularly in the wood, is brought about by fungi. The woody substance by becoming soggy and taking up much moisture, soon becomes the abode of a host of decomposing agencies, both fungi and bacteria, as well as small animal organisms and burrowing and boring insects. Disintegration follows when the parts become soft and brittle and yield to such forces as wind, rain, snow, gravitation, boring insects and beasts and birds, of which gravitation is the chief.

A knowledge of the mode of disintegration of the woody parts is of great value in the study of coal, as the state of division of the woody components of peat closely parallels that of the corresponding components of coal. Examination of the chips of wood in peat shows by far the larger number are small flat thin pieces; many of

these pieces may be separated into several thinner ones. (Pls. IV, VI, VII, and VIII.) Examination of the anthraxylon pieces in coal shows a similar condition. There is a reason why the stems of trees or shrubs should form such pieces on disintegration.

Several modes of disintegration can be recognized, each one resulting in similar flat and thin, or scaly, woody remnants. In peat the most prevalent condition and the one most frequently recognized in disintegrated parts of conifers, is caused by the exfoliation of the annual growth rings through differential decay. As is well known all stems of exogenous plants grow through an annual increment of new wood or fibers developed in the phloem, which lies between the wood and the bark; but this growth is not uniform throughout the growing season. During part of the time the cells grow much faster than at other times and the cells become relatively large while the cell walls remain relatively thin thus forming what is known as the spring wood; then at other times the growth is slower and the cells added are small and the walls relatively thick, and the increment is known as autumn wood. At one time of the growing season, the "incrustation" of the cell walls may be slight, and at other times relatively heavy. Certain parts of the growing ring therefore decay more readily than others, and in consequence lesions are formed in the regions that decay the more easily. When the whole stem or piece of wood has reached a certain stage of decay and has become soft and brittle, it gradually falls to pieces through any slight disturbance, or its own weight. Disintegration takes place by means of exfoliation along those growth rings that have decayed most, resulting in many thin tangential leaflike sheets that easily break up into smaller fragments.

Some trees are more subject to this mode of disintegration than are others. The basswood (Tilia Americana) is a well known example. The stem of this tree at a certain stage of decay may be peeled off and separated into large thin sheets that easily break into smaller pieces. A casual examination of the detritus of a peat bog reveals numerous wood fragments of greatly varying size in a similar state of division. (Pls. IV–VIII.)

A second mode of disintegration is by splitting along the medullary rays. This method appears to be common in trees with broad rays, as the elm and the oak. The ray cells decay more readily than the other parts of the wood. In trees with broad rays the lesions are formed along radial planes, and when the wood has reached a certain degree of decay it will separate along those weakened planes. The result is similar to that of disintegration through exfoliation along the annual growth rings, except that thin radial plates are formed instead of tangential plates.

Many of the trunks and larger stems, or the larger parts of them, withstand the mechanical separation and disintegration and are gradually buried by the débris of subsequent years. These are, however, in various stages of decay and are infested with bacteria and fungal growths, although occasionally a stem is found that is apparently sound. Usually they are covered with a profusion of polyporus fungi, lichens, and liverworts.

COMPOSITION OF A BOG.

On the surface of many peat bogs in central Wisconsin, besides the plants still living are trunks and stems of trees, limbs and branches in various lengths, pieces or chips of wood of various sizes and shapes, leaves, mosses, lichens, liverworts, and fungi in various stages of decay and maceration; particularly noticeable are the leaves or needles of the different conifers. (Plate III, *A* and *B*.) Settled between the interstices of the débris are fine bits of anything that happens to grow in the swamp, the material that furnishes the fine microscopic débris, or attritus.

Beneath the uppermost strata is a wet mass of more or less macerated plant débris, a soil of black mud, containing many fragments of semidecayed wood. This mud, which may be from a few feet to 30 feet or more deep, is filled with trunks of trees more or less whole and pieces of trunks, roots, and branches of all sizes in various stages of decay. The contents of the whole swamp from the bottom up is similar to that of the surface layer.

By far the larger part of the mass is water.

THE COMPONENTS IN DETAIL.

THE ATTRITUS.

When the amorphous appearing mass, the black mud, is examined under a miscroscope it is found to be composed almost entirely of definite and specific particles recognizable as portions of plant tissues or organs; only a relatively small amount is amorphous. Among the recognizable particles are whole cells or parts of cells and small complexes of cells of many descriptions; bits of tissues of many kinds of plants; parts of various organs, such as root hairs and rootlets; moss protenemas, parts of mosses, fungal hyphi, bits of leaves and bark, pollen grains, spores, bits of leaf cuticles and resin particles. These are all miscroscopic in size and would form a very fine silt if separated from the rest of the peat. If in dried condition they would form a fine dust or attritus, and will, therefore, be called the *attritus*.

OBJECTS VISIBLE UNDER A HAND LENS.

The most familiar components that may be examined under a hand lens or low-powered microscope are very small bits of woody tissues, parts of various herbaceous tissues, parts of rootlets, the whole or parts of moss plantlets, small pieces of bark, parts of leaves of angiosperms, gymnosperms, and grasses, and especially cuticles.

The woody parts of the plants show a gradation of sizes from the most minute to that of almost whole stems or logs. The gradation of the smaller woody components is of special interest and significance because these pieces are of a peculiar nature.

THE SMALLER WOODY COMPONENTS.

In a lump of peat taken from a woody Wisconsin swamp (Pl. IV, *A*), wood forms a large proportion of the components and the largest proportion of the woody components consists of thin, flat pieces, ranging in sizes from those easily visible to the naked eye to those about the size of a postage stamp. (Pl. VI.) When closely examined they are seen to be either tangential shells formed through an exfoliation along the spring wood of an annual ring or through a rupture of the decaying wood along the ray parenchyma of the stem or log.

When wet these chips or pieces may easily be split into still thinner ones; on drying, the cells collapse and the pieces become very thin and hard. (Pl. VII, *A* and *B*.) The tangential shells are chiefly derived from coniferous trees, and the radial plates from angiosperms. Other modes of disintegration may be observed, but as they are chiefly of interest in the transformation process, they need not be discussed here.

LARGER WOODY COMPONENTS.

The larger woody components are broken limbs, twigs, branches, and roots. Most of them are rather short, cylindrical pieces, although some are fractured or split, and they are in same condition of decay as the chips.

LOGS AND LARGER PARTS OF TREES.

The numerous logs and larger parts of trees encountered in sounding a bog are in various stages of decay. Usually the deeper the log is embedded the more it is decayed. Toward the surface may be some in which the wood is still hard and sound. Often trunks are found in which an outer shell has been transformed into a mushy or plastic mass, whereas the central portion is still hard and sound. Most of the logs, particularly those some distance below the

surface, have been transformed into peat and may easily be penetrated with the sounder or cut with the spade. The wood in these is in the same condition as that of the smaller fragments. The pulp of many of such buried logs varies in color from a yellow to a light brown when first taken out, but after exposure to the air it soon turns dark brown, the usual color of peat.

PROPORTION OF COMPONENTS.

The proportion of any of the components in a sample of peat from a bog varies considerably according to the depth, the place in the swamp, and the particular bog from which the sample is taken.

The ecological conditions, which determine the accession of different plant societies, change materially from time to time during the history of a bog; the conditions of several parts of the same bog may differ considerably and those of several bogs may differ so much as to cause the plant societies in each to be altogether different. The kinds of plants that contribute to a bog determine largely the degree of maceration and, naturally, the plant remains found in a bog.

SPORES, POLLENS, CUTICLES, AND RESINS.

A few of the components mentioned form a relatively small part of the total plant products, but are of great importance in the final composition of the deposit. These are the spores of Pteridophytes, pollen grains of both Gymnosperms and Angiosperms, the resinous parts of many plants, especially conifers, and the cuticular tissues of plants, particularly the cuticles of leaves.

The spores of most all the Pteridophytes, like those of the ordinary ferns, the horse-tails and the ground-pines or clubmosses (Plate VIII, *B*) have comparatively thick outer coats or exines composed of a mixture of resins, waxes, oils and cutocellulose, that are resistant to decay. Likewise the pollen grains of all plants contain a spore-coat or exine of similar composition, although they are much thinner than those of the Pteridophytic spores. The cellulosic plant products, that is, the woody parts, largely decompose and are lost to the deposit, whereas the spore-coats decay relatively little. There is consequently an enrichment or concentration of the more stable components, which are therefore, present in the final product in appreciable amounts. The annual increment of the cellulosic part of plants over the annual production of spore-exines is not large and in some cases the two are nearly equal. Therefore, the total production of exine matter during the whole life of the plant is not small in comparison with the total mass of woody tissue.

The same is true for the cuticular tissues. It is well known that all leaves and needles, the younger stems, and often also the older

stems, fruits and berries are covered with a membrane of a composition similar to that of the spore and pollen exines and equally resistant to decay. Although in many plants this cuticle is very thin, in many others it is thick. In the needles of conifers and many ferns the cuticle is well developed. (Pl. IX, *A* and *B*.) Often there is an additional layer of wax laid over the cuticular membrane, and sometimes there is on the film of wax a coat of fine hair, processes, or fine granules, also composed of a waxy substance. On the leaves of some plants the coat of wax is so thick that it is commercially valuable. Occasionally both saturated and unsaturated higher paraffins, the most resistant substances known, are present in such cuticles.

The resinous matter in peat deposits originates in various ways. Almost all coniferous trees contain so-called resin cells distributed throughout the wood. Some conifers, as the tamarack, contain fissures and reservoirs in which resinous matter is collected. Often these reservoirs are so large that the amount of resin contained in a single tree may amount to several gallons. In the bark of coniferous trees the resin occurs in the parenchymatous cells and blisters or in reservoirs as in the balsam fir (*Abies balsamea*). The resin in the genus Pinus amounts approximately to 10 per cent of the dry weight. Flowering plants as well as the conifers may contain resinous matters both in the wood and the bark. The leaves and needles of the conifers and of the flowering plants may also contain much resinous matter. Resinous matter is not subject to bacterial decay and is left behind when the resin-containing tissues or organs have disappeared through decay.

THE AMORPHOUS CONSTITUENTS.

A varying amount of the mass of peat is in an amorphous state. It is surprisingly small, and is composed of plant matter so finely macerated as to have lost all cell structure. Careful examination shows a gradation of sizes of the particles composing this attritus, the particles ranging from those easily visible under the microscope down to those in a colloidal condition and visible only by ultramicroscopic means.

Some of the larger particles show characteristics of the cell, others have lost all such identity.

All these particles are poorly defined and are usually ragged and rough in appearance. When examined by ultramicroscopic methods a large proportion of them are seen to consist of numerous submicroscopic particles or micelli, loosely united and having large intermicellar spaces between them.

THE PHYSICAL STRUCTURE OF THE TISSUES REMAINING IN PEAT.

After the excess water has been allowed to drain off completely, a mass of peat or any piece of wood in it, if compressed, will give up a large amount of water, and even when air-dried peat contains from 12 to 17 per cent of water. This indicates that the mass is in a peculiar physical condition.

Almost any of the pieces of wood taken from a matured part of the bog is found to be quite plastic, and may be kneaded much like clay. When a piece of such wood is partly dried it has a consistence similar to that of art gum; when completely air-dried, it has a horny consistence, sometimes resembling hard rubber.

When the wood is examined in thin sections under a high powered microscope the cell walls are seen to have a granular structure and no longer appear compact and homogeneous as in living or sound wood. The cause of this granular appearance becomes evident when the cell walls in very thin sections are examined by ultramicroscopic means. The cell walls are composed of innumerable very fine particles or micelli with relatively large intermicellar spaces that are filled with water. This is true not only of the cell walls of the woody components but also of the walls of all those that at one time were composed of cellulosic or lignocellulosic matter. As all plant tissues, aside from a few adventitious substances and the little inorganic matter in them, are composed of cellulose or lignocellulose, cell walls of practically the whole mass are in this peculiar condition.

There is a wide range in this condition of the mass, depending largely upon the maturity of the peat. This condition is a phase of the transformation of the living plant substances into peat and eventually into coal. In the Wisconsin bogs under discussion, which averaged from 8 to 13 feet in depth, the condition became more uniform with depth. In other words, the older the deposit the more mature is the peat and the more uniform its physical structure. The greatest difference in structure is found at the surface and within a few feet of it.

Moreover, the further the mass has advanced toward a uniform condition the less cellulose and lignocellulose it contains. In well-matured peat no cellulose or lignocellulose can be detected by the methods of test generally applied. The change of the physical condition of the wood parallels the chemical change.

THE CELL WALLS IN A STATE OF HYDROGEL.

As has been shown, the remaining cell walls of the components of peat are an aggregate of extremely small particles or micelli and these micelli are not visible with the ordinary microscope. A collection of such particles, whether suspended in water or whether

packed closely together with only thin films of water or air between them, is termed a colloid. When such fine particles are suspended in water the colloid is called a hydrosol or colloidal solution; if the particles are so closely packed together as to be separated by only a thin film of water, the particles having lost their individuality and holding together to form a jelly-like mass, the colloid is called a hydrogel. The remaining cell walls of the plant substances in peat are in a state of hydrogel.

It is well known that when the particles of any substance in such a fine state of division are brought close enough together—that is, within the radius of their sphere of attraction—they form a solid mass. If a mass of jelly, which is a hydrogel in terms of colloidal chemistry, is left to dry it forms a hard mass for that same reason. For that reason, also, when the woody components of well-matured peat dries they form a hard brittle mass; likewise all the peat will form a hard brittle mass when dried provided the peat is well matured, or in other words if the cell walls comprising it have approached a typical hydrogel. The more matured the mass, the harder and the more coal-like will it be when dry.

Peat in any stage of maturation may be transformed by artificial means into a typical hydrogel, and such a mass when desiccated will resemble coal very closely, in fact it will be harder and more solid than many bituminous coals.

OTHER PROPERTIES OF PEAT.

Besides its property of forming a hard mass when dried, peat owes many peculiar and striking properties to its colloidal condition. To call attention to a few of them may be of value. The property of retaining water with tenacity has caused difficulty in commercializing peat as a fuel. The absorption of gases, particularly oxygen, has been variously applied. Peat absorbs odors readily and for this reason is a valuable stable litter. It absorbs various substances in solution; aids in decomposing certain compounds in solution, especially electrolytes that dissociate easily; and it is a strong reducing agent.

PRESERVATION OF PLANT TISSUES.

The mechanical cell structure—that is, the form and the shape of cells of the woody components from the most minute fragment to the largest present—has been well preserved in peat, the cells and fibers having retained their original form and shape remarkably. Only occasionally have the walls become very thin and collapsed. Fragments of other tissues, particularly those of the mosses, have retained their cell structure to a similar degree. Leaflets and whole

or nearly whole plantlets may often be found with every detail of their organization retained. Often parts of succulent stems are found similarly well preserved, although it is chiefly among the latter that the cells have collapsed.

As there is no further mechanical change in the components, after they have been submerged under subsequent matter, except a complete collapse of the cells caused by downward pressure and the withdrawal of the water, the finding of so much well-preserved plant structure in the coals, as is shown later, is not surprising. After the plant residue is once covered it is practically removed from all mechanical agents and no further maceration takes place.

STRUCTURE IN COAL.

GENERAL APPEARANCE UNDER THE MICROSCOPE.

Coal may now be examined with a clearer understanding of the terms and a more intelligent interpretation of the characters observed, because, as the author believes, coal deposits and peat deposits have been formed in analogous ways, and because the constituents in coal and peat are analogous in every respect, except that the plants that contributed to the deposit of each differed in kind. although not materially in cell structure and chemical composition.

For a general study of the outward appearance of bituminous coal a lump or block from almost any bituminous coal might be selected. Pieces of coal from the Pittsburgh bed near Pittsburgh, Pa., (Pl. XXXVI, *B*), from Sesser, Ill. (Pl. X), from the mine of the Benton Coal Co. near Benton, Ill. (Pls. XI–XIII), and one from the Vandalia mine near Terre Haute, Ind. (Pl. CXLII), have been chosen for the illustrations shown in the report, as they will illustrate the microscopic appearances of any ordinary bituminous coal.

THE LAMINATION SEEN IN COAL.

A bed or bank of any bituminous coal is readily seen to be laminated (Pl. XXXVI, *A*); likewise a block or lump of coal when examined more closely is seen to be composed of many layers or seams differing from one another in color, texture, fracture, degree of absorbing and reflecting light, and differing greatly in thickness (Pls. X–XIII; Pl. XXXVI, *B*, and Pl. CXLII).

A little study shows that in general there are two kinds of layers or striæ. One is jetty black, and usually has a high luster, reflects light readily, is more compact and breaks with a decidedly conchoidal fracture; the other is grayish black, has a dull appearance, and little or no luster, does not reflect light as readily but rather refracts it, is less compact and breaks irregularly. The former is

usually found as lenses of varying thicknesses and widths and on close examination is seen to be embedded in the latter; this last characteristic is most evident in extensive exposures or in large blocks. Even with the naked eye, after a careful examination, the duller layers or striæ are seen also to be composed of numerous thin alternating bright and dull sheets. This is brought out clearly and distinctly in a polished vertical section slightly magnified.

When coal is examined along cleavage surfaces parallel to the bedding planes, it is seen to contain charcoal, also called "mother coal" or mineral charcoal, in thin layers or laminæ. As the charcoal stands out prominently on the horizontal cleavage faces and is readily recognized, even when present only in small quantities or thin sheets, the earlier observers distinguished only two classes of coal—compact coal and charcoal.

But when coal is examined along the vertical cleavage surfaces only, the charcoal appears as dull coal, is overlooked, only dull and bright laminæ being observed.

As regards types of components, ordinary bituminous coal may be said to have three, dull coal, bright coal, and charcoal; but as regards differences in compactness or hardness, coal may be said to have two components, compact coal and charcoal, as described by earlier investigators. In the latter classification the dull laminæ and the bright laminæ of the compact coal must be distinguished.

Although these differences have been recognized from an early date, no complete or definite explanation of the true nature of dull and bright laminæ in the bituminous coals had been offered, or, if correct interpretations have been given in part, no definite proof of their differences has been offered. One of the objects of this bulletin is to show the real nature of the dull and bright laminæ.

THE "BRIGHT COAL" OR ANTHRAXYLON.

The most prominent features in Plates X–XIII are the broad black bands running through these pieces—the so-called "bright coal," "jet coal," or "glanz coal" of other authors. These black bands are most always lenticular, or broad, flat pieces that have a wedge-shaped termination. The black bands run for some distance through a larger block or even a long distance through the coal in the seam before they terminate. In a small piece of coal they generally continue through the piece from one side to the other, and for that reason convey the idea of laminæ or layers instead of inclusions, but it is not rare to find complete lenses or their edges in small blocks. Such terminations are shown in Plate XI, *A* and *B*, Plate XII, and Plate XIII.[a] The bands of the bright coal should there-

[a] White, David, and Thiessen, Reinhardt, The origin of coal: Bull. 38, Bureau of Mines, 1914, pp. 140–155.

fore properly be called lenticular laminæ. These lenticular laminæ vary in thickness, but are rarely more than 10 mm. or three-eighths of an inch thick. The layers shown in Plates XII and XIII of coal from the mine of the Benton Coal Co. are about 9 mm. thick and are rare. The thickest layers in the coal from Sesser, Ill. (a, Pl. X), measure between 4 and 5 mm. and are of common size. The layer a (Pl. XXXVI, *B*) of coal from the Pittsburgh bed is 9 to 10 mm. thick. The other layers in this block are very thin, a characteristic of the coal from this bed. All these black bands shown in the photographs—the so-called "glanz coal," "jet coal," "bright coal," "humus coal," of various authors—represent parts of definite components of the woody parts of plants; that is, parts once pieces of logs or stems, branches, twigs, and roots, but now much compressed. They correspond to the larger pieces of woody peat, such as pieces of logs or stems, branches, twigs, and roots. Being definite pieces of coal derived from wood, these components are called *anthraxylon*, meaning coal wood, from *anthrax*, coal and *xylon*, wood.

THE "DULL COAL."

The characters that stand out next in prominence in Plates X–XIII are the lighter striated bands or layers between the dark bands. These represent the so-called "dull coal," "canneloid coal," "matt coal" of other investigators, because they have a dull look compared with the layers of the "bright coal."

This dull coal is composed of a general débris derived from a variety of plant products and corresponds to the general débris of peat deposits. When the vertical face of a large block or of a coal bank is examined the black and brighter bands are not continuous, but are definite objects embedded in or surrounded mostly by the "dull coal," exactly as the larger pieces of woody peat are embedded in the "black mud" or general débris.

A more careful examination of the "dull coal" shows that this in turn is composed of many thin light and dull sheets. In many coals this thin sublamination is well defined, as is shown by Plate XI, *A*, and Plate XXXVI, *B*. The brighter sublaminæ again, represent components derived from smaller pieces of woody tissues and hence also are anthraxylon components that correspond in every respect to the smaller fragments or woody chips in peat, such as are shown in Plate IV-VIII. These, like the larger anthraxylon components, vary greatly in size. There is a complete gradation of thickness from the thinnest anthraxylon, but a few microns thick, to the larger anthraxylon, many centimeters thick; so that the distinction drawn between the larger and the smaller anthraxylon components is arbitrary. But as the thickness of a relatively large number of the

smaller components varies within certain limits, the distinction between "dull coal" and "bright coal" holds for most coals.

THE ATTRITUS.

That part of the "dull coal" in which the smaller anthraxylon chips are embedded, represented in gray or the lighter thin sheets in the photographs, is finely divided matter and corresponds to the fine black "mud," or attritus of peat, and, as will be shown later, is similarly composed. This component of the coal will, therefore, be called the attritus.

The attritus forms the groundmass in which the smaller components, such as the smaller anthraxylon, cuticles, and megaspores are embedded in the same way that the mixture of sand and cement in concrete forms the ground mass for the crushed stone and gravel, and it is designated the general débris which forms the so-called "dull coal." This general débris or "dull coal" in turn is the embedding medium of the larger components in coal, in the same way that the mixture of cement, sand, gravel, and crushed stone forms the embedding medium of the larger stones in concrete.

The characters described above are true of all ordinary bituminous coals, and coals from any locality might have been chosen equally well for illustration. A careful study of lumps of any bituminous coal that may be at hand will show the proportion of the dull layers and bright layers to each other, and the sublamination of the dull laminæ into many thin bright and dull sheets.

EXAMINATION OF VERTICAL SECTIONS AT LOW MAGNIFICATION.

The mode of the fine lamination is seen much better in a vertical section at a relatively low magnification, either in a polished opaque section by means of a reflected light or in a thin section by transmitted light. Examination in the latter way is an essential step from the gross aspect, or macroscopic appearance of coal, to its appearance in thin sections at relatively high magnification. It is also essential in obtaining the relationship of the woody components to the attritus as well as the relative proportion of the two. Representative sections of this kind, magnified 10 diameters, are discussed in detail.

In the photographs the larger anthraxylon components or "bright coal" are designated by the letter a, while the "dull coal," or general débris, represented by gray, finely striated areas or bands, is designated by the letter d. The numbers preceding these letters indicate either the order or situation in the photograph or refer to the same layer or band in some other photograph with corresponding letters and numbers.

STRUCTURE OF THE COAL FROM THE BENTON MINE, BENTON, ILL.

The coal from the Benton mine, near Benton, Ill., is relatively simple in structure and shows defininite alternation of so-called bright laminæ and dull laminæ. The macroscopic appearance of a piece of this coal is shown in Plate XII.

Plate XV represents a section of the piece of coal represented at natural size in Plate XII, from the area formed by the intersection of the lines xx, yy, and nn, mm, magnified 10 times. The bands or striae 1–a, 2–d, 3–a, 4–d, 5–a, 6–d, 7–a, and 8–d in Plate XV are the same as those of the same lettering and enumeration in Plate XII. Beginning at the top of the photograph there is, first, a layer of bright coal or anthraxylon, 1–a, containing a fissure filled with quartz; then a layer of débris or "dull" coal, 2–d; next a thin piece of poorly defined anthraxylon, 3–a, between the layers of débris, 2–d and 4–d. In the middle of the photograph is the relatively thick piece of anthraxylon, 5–a, containing a characteristic vertical fissure, filled with quartz. Below this piece are very thin alternating sheets of débris and anthraxylon that grade into the débris, 6–d. This grades off similarly into the anthraxylon, 7–a; finally, at the bottom is the débris, 8–d, which includes a small piece of charcoal, c.

The illustrations show a vertical surface of the coal; that is, a cut perpendicular to the plane of the bedding; hence merely the cut edges or the ends of thin sheets of débris and of woody fragments are seen. If the piece of coal were split along the bedding planes these thin and flat components would be seen in their horizontal positions. Such horizontal cleavage surfaces will be discussed later and correlated with the cross sections. (For horizontal cleavage planes see Pls. XXV–XXX.)

The photograph (Pl. XV) clearly shows that the laminæ of débris or "dull coal," designated by 2–d, 4–d, 6–d, and 8–d, are in turn composed mainly of two constituents, the one gray and the other darker, arranged more or less in alternating horizontal sheets. A closer inspection shows that many of these sheets extend across the photograph, others terminate in it, and many lie entirely within its borders. If the sections were wide enough all the sheets would be seen to terminate within a comparatively short distance. Some, as seen in cross section, are linear, others slightly lenticular, and still others more or less irregular. The dark sheets for the most part were at one time small fragments of woody matter analogous to the smaller chips forming an important part in peat (Pl. VI) and are the smaller anthraxylon components. The gray sheets are for the most part the finely divided matter derived from various sources, including the spore matter, and hence are the attritus.

Plate XVI is taken from the same piece of coal, though from another side and higher up. It shows but one thick anthraxylon strip in the center, 2–a, and a part of a thicker one at the bottom, 5–a. The "dull coal" at 1–d, above the anthraxylon 2–a, is regularly grouped into dense, narrow long patches separated by black strips derived from woody tissues of plants. When these patches of débris are examined closely they are found to be laminated further into light and dark strips, the lighter representing attritus and the darker, anthraxylon. In this part of the "dull coal" thin, well-defined light lines may be observed, double in several places; these are the edges of cuticles. The sheets of attritus are more or less contorted at 3–d to 4–d, as if they were folded upon themselves. The black or anthraxylon components also are irregular. In other respects the components are similar to those observed in Plate XV. The gray areas are analogous to the black mud in the peat bog, are similarly composed, and are plainly attritus.

STRUCTURE OF THE COAL FROM ROYALTON, ILL.

The coal from the Royalton mine presents fairly the average structure of the Illinois coals. Instead of showing the macroscopic aspect of this coal in a lump, a continuous area in cross section of about three inches thickness and about one-half of an inch in width of the coal is presented at a magnification of 10 diameters as a series. (Pls. XVII–XXI.) Such a continuous strip shows both the general proportion and the structure of the main components over a known thickness. If Plate XVII alone were examined, it would give the impression that the coal was composed largely of matter derived directly from wood; if, on the other hand, Plate XIX alone were examined, it would give the impression that the coal was composed of débris only. The three inches of thickness, however, shows average conditions in the compact coal at the Royalton mine, exclusive of layers containing much earthy matter, pyrite, or charcoal. A similar illustration of coal from the top to the bottom of the bed would show only minor differences.

At the top of Plate XVII, 1–a is a thick woody or anthraxylon strip; the irregular strip h running from side to side is the last vestige of the inner part of a hollow stem, such stems being common in many of the woody components in all coals. Below the anthraxylon 1–a is a "woody" débris, 2–d. The fine line, in about the middle of this sheet, running almost across the photograph is the cut edge of a leaf cuticle. Then 3–a is another anthraxylon layer. The irregular streak running through this part is a fracture, such as often is seen in the thicker anthraxylon components. Below this is a layer of débris, 4–d, in which the constituents are lumped into lenticular

or wedge-shaped masses; 5–a is a thin piece of anthraxylon, showing clearly its lenticular shape; 6–d is a layer of débris, rather woody in the upper part and less woody in the lower part; 7–a is another anthraxylon piece with a characteristic fracture running through it. In the débris (8–d, Pl. XVIII) the cut ends of the so-called rodlets, very common in most coals, are noticeable. At 9–a is another piece of woody coal without a horizontal fracture but containing a vertical fissure filled with quartz. The remainder of the photograph is an anthraxylous débris, 10–d. The darker strips are mostly thin chips of anthraxylon, and the lighter parts are an attritus of finely macerated plant products. This attritus is shown in detail later (Pl. CVI). In 10–p is included a chip of semi-petrified wood. The lower part of this layer, 11–a, is very anthraxylous. Plate XIX and a part of Plate XX shows a thick layer of débris, 12–d to 15–d. In 13–c is included a lense of carbonized and petrified matter, and from 16 to 21, Plate XX, several anthraxylon chips alternate with débris. A thicker anthraxylon layer at 22–a is evidently a part of a hollow stem including some débris, 23–d. In the lower section of this part of the stem the evidences of remaining cell structures are clearly recognizable, even at the low magnification. The remainder of the 3 inches of coal (24–d to 26–d, Pl. XXI) consists of relatively pure débris, with but one thick anthraxylon chip, 25–a. A number of the so-called rodlets are noticeable in this section, particularly from 25–d to 26–d. Plate XXII, *A*, which is not a part of the above series, shows a layer in which a large number of these rodlets are seen in cross section. Plate XXII, *B*, magnified 10 diameters, shows clearly the structure of the constituents of this coal, with inclusions of charcoal in the lower part.

STRUCTURE OF THE ZEIGLER AND HART-WILLIAMS COALS.

The structure of the coal from the Zeigler mine, as shown in Plate XXIII, does not differ materially from any of the other coals shown; it is very similar to the coal from the Benton mine. Attention is called to the lumping of the débris in several places, and also to the cross sections of rodlets in the upper half, a characteristic of these coals. The section shows, with the exception of the woody elements at the top and the bottom, 1-a and 5-a, a lamina rich in attrital matter. Another section from the same coal (PL. XXIV, *A*) shows the dull coal is in very delicate, sharply defined, thin strips consisting chiefly of cuticles. The interpretation of this section is given in the discussion of the Zeigler coal at higher magnifications (p. 85). Similar sections are found at various horizons not only in the Zeigler coal but also in the Benton and the Hart-Williams coals.

The structure of the coal from the Hart-Williams mine, near Benton, Ill., is similar to that of the coals from the Benton and the Zeigler mines and needs no further discussion.

STRUCTURE OF THE COAL FROM SESSER, ILL.

The structure of the coal from Sesser, Ill., as seen in cross section, is much like that of the other coals already discussed. The section shown in Plate XXIV, *B*, is mainly anthraxylous. The relatively thick anthraxylon components of the débris are separated by relatively thin sheets of attritus. In the anthraxylon component at 2–a the remains of the original cell structure are clearly shown. Plate CI, *A*, shows this part of the section at a magnification of 200 diameters. Compare Plate XXIV, *B*, with Plate C, *A*, prepared by transmitted light but at the same magnification.

STRUCTURE OF THE COAL FROM BUXTON, IOWA.

Plate CXXI, *A* and *B*, and Plate CXXII, *A*, represent cross sections of the coal from Buxton, Iowa. In general the structure of this coal is similar to that of other coals. Two prominent characteristics are the frequent presence of megaspore-exines and sporangia and the peculiar nature of the smaller anthraxylon strips. A number of large megaspore-exines are distinctly seen at 4–sp, also a number of sporangia filled with spores at 2–s and part of a cuticle at 5–c, Plate CXXI, *A*.

STRUCTURE OF THE PITTSBURGH COAL.

The Pittsburgh coal in the block (Pl. XXXVI, *B*) contains only a few thicker laminæ of the larger anthraxylon components. It is characterized by relatively thin alternating sheets of dull and bright coal rather uniformly arranged. The character of the structure is seen much better in vertical sections at a relatively low magnification.

Instead of illustrations giving a continuous strip, Plates XXXVII–XLI, taken at 1-foot intervals from top to bottom of the 5-foot bed at the Oak mine are shown supplemented by illustrations from other parts of the same bed. As the reader is now presumed to be familiar with the general appearance of such sections, attention is called only to characters that are new or of special interest.

Scarcity of the thicker woody elements, uniform distribution of the components, and fine lamination are noticeable throughout the series. Plate XXXVII shows a cross section taken from the first foot of coal, measuring from the roof, of the coal at the Oak mine. A large proportion of the components are layered in very thin delicate sheets

with here and there oval inclusions. Megaspore-exines are recognizable everywhere, particularly at 4–d. Compare Plate XXXVII with Plate XLIV, prepared from the same sample by means of transmitted light at the same magnification, and note the appearance of the same components.

Plate XXXVIII shows a cross section of the coal from the second foot of coal from the top. The anthraxylon components, shown as delicate black strips, are both thicker and more numerous than in the coal from the first foot of the bed. At various horizons, as at 4–d and 5–d, there are indications that the anthraxylon components are not solid, but consist of a number of very thin sheets closely packed one upon the other. At 1–d a bit of semipetrified wood is included. Similar small bits are recognizable in other parts of the section. Compare Plate XXXVIII with Plate XLV, made by transmitted light at the same magnification.

In Plate XXXIX, taken from the third foot from the top of the seam, the distribution and the layering is more irregular. The proportion of the anthraxylon components has become larger than that shown in the two foregoing sections, and the attritus is somewhat lumped. Megaspores are seen in 2–d. Compare Plate XXXIX with Plate XLVI.

Plate XL represents a section from the fourth foot from the top of the seam. Although the general structure of the coal at this level is similar to that at 3 feet from the top, the photograph shows certain characters that can be seen more easily than they can be described. It has four groups of layers. The first one, 1–d and 2–d, has characteristics much like those shown in Plate XXXIX, but the one at 3–d is very irregular and contains a number of thick-walled megaspores; the next one, at the level 4–d, is more anthraxylous, the heavy black strips running across the photograph and representing thick chips; also a number of megaspores are visible. At 5–d is a fragment of petrified wood, and next to it is débris rich in spore matter. Compare Plate XL with Plate XLVII.

Plate XLI shows a cross section of the coal in the fifth foot from the top (the first foot from the floor). The coal is here decidedly more anthraxylous. Plate XLI and Plate XXXVII differ decidedly in the amount of anthraxylous matter present and also in the composition of the débris. Anthraxylous components of the thickness shown at the level 2–a (Pl. XLI) are quite common at this horizon of the seam. Compare Plate XLI with Plate XLVIII, *A*.

Plates XLII and XLIII present two different sections of the coal from the Pittsburgh bed at the experimental mine. The structure is similar to that of coal from the Oak mine, particularly the section 3 feet from the top.

The structure of the coal from the Oak mine and the experimental mine is characteristic of the Pittsburgh coal at any of the localities from which samples were taken, namely, Bruceton, Madison, Connellsville, in Pennsylvania, several unknown places, and near Hobart Street in Pittsburgh, and a mine in Ohio, near Moundsville, W. Va.

SIMILARITY OF VERTICAL SECTIONS OF ALL COALS.

The general appearance of the vertical sections of all the coals examined is much the same. Many sections of the coals have been compared and every one has revealed similar characteristics. Further, no matter from what coal the section was chosen nor from what part of the coal seam, these characteristics have been similar, as is shown in the illustrations. The conclusion, therefore, can safely be drawn that nearly all the ordinary Paleozoic bituminous coals are of similar structure, so far as can be learned from vertical sections.

EXAMINATION OF HORIZONTAL CLEAVAGE SURFACES.

Although the appearance of the horizontal surface fracture of coal has been the object of much discussion and has furnished material for a voluminous literature, some first-hand observations and original illustrations of it will be profitable for the sake of completeness and of having the matter immediately available and fresh in mind.

When, in the past, horizontal fractures have been discussed and illustrated, the woody structure seen on the surface has been termed charcoal or mother of coal; the fractures described were chiefly through larger pieces of charcoal. Frequently, also, objects described as charcoal were in reality pieces of solid anthraxylous coal, or the distinction between charcoal and solid anthraxylon components was not always clearly drawn, or the two were not clearly identified. Although there is a clear distinction between the ordinary woody components of the compact coal and the average charcoal observed, no hard and fast line exists between the two, as they are to some degree intergradient or transition forms.

In this report cleavages through the compact coal only are referred to, and splits through charcoal are ignored as far as possible or very carefully avoided. The discussion refers to compact coal and not to charcoal.

It is not always possible to obtain a good horizontal cleavage in any or every desired horizontal plane of any coal. Some coals split much better than others; the more compact the coal the greater the difficulty in obtaining a good split. The Pittsburgh coal proved the most difficult to split in any desired lamina, whereas the coal from the Vandalia mine near Terre Haute, Ind., although very com-

pact, splits with comparative ease; however, with some care and by using a small block, enough cleavage faces for satisfactory observations may be had from any coal. In the more compact parts of a block the fracture will often run across the anthraxylon components and thus fail to give a full exposure of all of them. This condition is shown in Plate XXXIV, *A*, from the Ziegler coal, which is typical of such fractures. The dark, irregular, heavy black lines or areas represent the oblique or more or less vertical fractures across the anthraxylous laminae.

STRUCTURE OF THE VANDALIA COAL.

The Vandalia coal splits with a clean, smooth surface in which certain characteristics are distinctly exposed and sharply defined. It is therefore remarkably well adapted for examination and photography for this purpose and may well serve to illustrate a general condition in coal. Plates XXV and XXVI, magnified twice the natural size, are taken from cleavage surfaces of horizontal fractures through the lump of coal shown in Plate CXLII, at the levels x x and y y, where the lump is compact.

On these surfaces are certain areas or patches showing woody structure and other areas, partly or wholly surrounding the former, that are practically structureless. The former look like small chips of wood or impressions of such chips embedded helter-skelter in a structureless mass. Some of the patches are isodiametric, others are long and slender, some have straight edges and sharp corners, others are rounded or irregular, and some look like mere slivers, being long, slender and sharp pointed. In general the grain of the wood is clearly seen.

The most characteristic feature is that the patches are all relatively small, as shown in the photographs. As the fractures are generally clean cut and the whole patch is exposed, the photographs present accurately their relative sizes (twice natural size) and general appearance. A slight difference in the general form and also in the sizes of the patches with woody structures will be noticed in the two surfaces.

Fine "rodlets" or "needles" may be recognized scattered over these cleavage surfaces. Some of them lie helter-skelter in the structureless areas; others are in the woody patches and evidently form a part of them. Remnants of cuticles may also be observed in some of the structureless areas.

STRUCTURE OF THE BENTON AND HART-WILLIAMS COALS.

The features so clearly seen in the Vandalia coal are repeated in the group of coals from the No. 6 bed of Illinois, though not in so clear

and convincing a manner. Wherever a cleavage is made through the dull laminæ, the surfaces exposed consist of similar patches of woody structure and structureless areas, together with a sprinkling of the so-called needles or rodlets, and occasionally a patch of charcoal. A larger structureless area, such as is shown in Plate XXXIV, *B*, is rarely seen.

Plate XXVII represents, in a little more than natural size, the cleavage surface through a compact layer of a piece of coal from the Benton mine. The structure of the woody patches may be seen distinctly. The patches cover the surface almost completely, as the fracture contains but few small structureless areas.

Plate XXVIII, *A*, represents a cleavage surface, at natural size, made a little obliquely through the block represented in Plate XI, *A* and *B*, at x, y, z (fracture 1). Although this surface has a larger total area of structureless patches and a large number of fine needles, the woody patches are scattered over the whole of it. Plate XXVIII, *B*, shows a cleavage surface in the same block at the level t, u, v, also somewhat obliquely across the bedding planes (fracture 2). The structureless area occupies about one-half of the total area, the woody patches lying somewhat like islets in it. The alternating layers are clearly brought out by the oblique fracturing and show better than anything else that woody patches are present throughout the coal. On the corner area at u the fracture runs through a thicker piece of bright coal or anthraxylon.

Plate XXIX represents fracture surfaces of the Hart-Williams coal. In the upper fracture the surface consists on the whole of woody patches. In the lower one the fracture runs mainly through a thicker piece of bright coal, showing, as do other fracture surfaces, the jetty inner appearance. The cell structure also may invariably be recognized in such a fracture.

STRUCTURE OF THE COAL FROM SESSER, ILLINOIS.

Plate XXX represents the cleavage surface through a piece of coal from the Sesser mine at Sesser, Ill. In this coal the same structure occurs. The many black irregular areas show where the fracture cuts through smaller pieces of bright coal; that is, through the interior of the woody patches.

STRUCTURE OF THE BUXTON COAL.

The Buxton coal in many respects has lignitic characteristics, and a study of its cleavage surfaces is of particular interest.

Its general appearance as seen in Plates XXXI to XXXIII, at low magnifications, are similar to the other coals. Besides the woody matter, a considerable amount of cuticle is exposed to the surface, as

is particularly noticeable in Plate XXXIII. The woody patches as in the other coals, are relatively small and have about the same shape and outline, but the cell structure is not so well defined, probably on account of the advanced decay of the woody element before coalification. However, enough of the structure is preserved to show a large-celled structure. In the woody patches themselves, as well as in the attritus surrounding the patches, numerous "rodlets" or "needle-like" bodies may be observed, as shown in Plate XXXII. (See the chapter on "Rodlets," p. 78.)

UNUSUAL STRUCTURE.

The horizontal fractures so far cited represent the usual or common structure. Some planes expose unusual features; although these differ much from the ordinary, they may be seen in any Paleozoic coal. Plate XXXV, *A* and *B*, show parts of a horizontal fracture, from the coal from Royalton, Ill., through a block containing a lamina similar to that shown in Plate XXII, *A*, along the horizon 3-r. In these surfaces are exposed a number of "rodlets," parts of petioles, bits of woody tissues, cuticles, and objects that resemble "rodlets," embedded in the attritus. (See chapter on "Rodlets," p. 78.) Similar surfaces are found that expose a large number of very slender rodlets instead of the thicker ones shown.

A large surface in which no woody patches and rodlets are exposed is very rare. Plate XXXIV, *B*, magnified ten times, shows a surface through layers of fine débris exposing an exceptionally small amount of woody structure. A few of the so-called rodlets are also seen.

SIMILARITY OF HORIZONTAL CLEAVAGES OF ALL COALS.

The nature of the horizontal cleavage surface has been shown to be similar in all coals examined. Many cleavage surfaces from different coals have been examined, and the structure is similar no matter where the cleavage is obtained in the compact coal of any ordinary bituminous coal, nor from what seam. Attention is called to the fact that cleavage surfaces in the compact coals only are mentioned and not those representing the so-called mineral charcoal or "mother coal."

The conclusion is that the cleavage surfaces in the compact coal of all ordinary Paleozoic coals are similar in character.

CORRELATION OF THE VERTICAL SECTIONS AND HORIZONTAL CLEAVAGES.

NATURE OF THE WOODY PATCHES.

The question arises as to whether the woody patches invariably seen on the horizontal cleavage surfaces are actual pieces of woody

coal or merely the impressions of woody structure and, if the former, are they the same woody components seen in the cross sections of the coal or something else.

On examination these patches are found to be very thin pieces of anthraxylon embedded in a finely divided ground mass or attritus and lying horizontally in every conceivable direction. The coal is largely composed of such pieces. Often they are so thin that a few scratches with a sharp-pointed tool, as a pair of forceps, will cut through one chip and expose another one beneath, sometimes with fibers running in another direction. Some patches are thicker, especially the larger ones, although their thickness is not always proportionate to their breadth and width. Some of the larger ones may be thin, and some of the smaller ones may be relatively thick, but as a general rule all are very thin. The woody patches that occur universally in the ordinary bituminous coals therefore are components and not impressions of objects that have disappeared.

These woody components are always present, no matter where a horizontal cleavage is obtained. In the cross sections, also, of any piece of coal the woody or anthraxylon components are seen to make up a large, usually the larger, part of the coal. The inference is that the patches are identical in both sections and cleavages. A close examination proves that they are in fact identical components, and also that the cell structures seen in a cleavage surface are not merely the impressions of some structure but are actually the fibers of pieces of woody coal.

ORIGIN OF THE WOODY PATCHES.

The origin as well as the nature of the woody components is shown to be analagous to similar components in peat. Comparisons of the general appearance of coal and peat in this respect establishes a proof of the origin of the woody patches in coal, and aids in obtaining a more comprehensive idea of the woody components and their appearance in horizontal surfaces.

SIMILARITY BETWEEN HORIZONTAL CLEAVAGE SURFACES OF COAL AND PEAT: A PROOF BY ANALOGY.

EXAMINATION OF SURFACES.

If a sufficient amount of well-matured peat is removed from a woody Wisconsin peat swamp, care being taken that its original and natural arrangement is not disturbed, and it is dried slowly until the mass hardens, the lump will be laminated similarly to coal, except that the layering will not be so definite, because the peat has not been greatly compressed. Often a lump of peat may be split horizontally along certain planes or bedding layers with a smooth,

clean-cut surface. When such a horizontal surface is examined macroscopically or with a binocular microscope, the constituents present may be readily observed. A number of thin flat chips of wood parallel to the bedding, the origin of which was discussed in a previous chapter, and a few thicker ones, are characteristic in this surface, and deserve special attention.

The series of Plates IV to VI were prepared from horizontal surfaces of peat. A casual comparison of these with the horizontal cleavage surfaces of coal shows a close resemblance, although the plants that contributed to peat differed in kind and organization, if not in cell structure, from those that contributed to coal. In the surfaces of both are seen the characteristic thin flat chips of woody components, the narrower slivers and thicker pieces, cuticles of leaves, occasionally parts of leaves themselves, and here and there parts of petioles and bits of stems or rootlets, all embedded in the general attritus. Instead of seeds or seed coats, the coal contains sporangia and megaspore exines. No equivalent in peat has been discovered for the rodlets in coal. The closest resemblance to peat is seen in the cleavage surfaces of the coal from Buxton, Iowa (Pls. XXXI–XXXIII and Pl. CXXIII), which is a low-grade coal and has retained lignitic characteristics.

DISSECTION OF HORIZONTAL CLEAVAGES.

Proof that the woody patches seen in the horizontal fractures are identical with the woody components seen in the vertical sections may be obtained directly in several ways. The method of selecting a small block of coal with a smooth vertical edge and splitting it in any desired lamina with a sharp knife, under the binocular microscope, is the most reliable. A piece of compact coal will not always split in the desired plane, but enough cleavage planes can be obtained in any desired lamina to obtain conclusive results. Some coals split much more easily than others; as already stated the coal from the Pittsburgh bed was the most difficult to split along any given horizontal cleavage plane, and the Vandalia coal was the easiest. Another method is maceration by means of Schulze's reagent, when not used in solutions too strong. After long treatment in a weak solution of Schulze's reagent most coals come apart in very thin laminæ or sheets, so that the woody or anthraxylon components may be lifted out with a pair of fine forceps or needles. In this way layers of considerable thickness may be dissected. Therefore, no doubt remains that the woody or anthraxylon components seen in cross sections and those seen in the horizontal cleavage surfaces are identical.

However, to remove all doubt, the origin of the patches in small pieces of wood or other plant tissues will be conclusively shown.

Thin sections and microscopic examination at high magnifications are required for this proof.

MICROSCOPIC EXAMINATION OF COAL.

STANDARDS OF COMPARISON.

In order to obtain a correct idea of the relative sizes of the actual and magnified sections standards of comparison are necessary. Without these, the illustrations at higher magnifications give an inadequate idea of the actual size of the objects or of the area of the coal section represented. This is particularly true of magnifications at 200 diameters and over. At a magnification of 1,000 diameters and more a concept of the actual size of the object or area represented is entirely lacking, without some standard of comparison, even in persons who are familiar with microscopic examinations. A correct idea of the size of an area represented at a magnification of 10 diameters is comparatively easy if the fact that the dimensions of the original are one-tenth of those of the photograph is borne in mind. If, for example, a photograph represented at a magnification of 10 diameters measures 5 by 7 inches, the area of the coal section represented measures 0.5 by 0.7 inch. But if the magnification of a certain object or area is 200 diameters, the actual size of the original area represented in the photograph is far more difficult to comprehend. If the photograph measures 4 by 5 inches, which is a little larger than most of the photographs presented, then the area of the original coal section represented in that photograph is only 1/50 by 1/40 of an inch. As the majority of the photographs at a magnification of 200 diameters measure approximately 100 by 120 millimeters, the millimeter is a more commensurate and convenient unit, and such photographs represent an original area of 0.5 by 0.6 mm. The dots and periods used in the printing of this bulletin are approximately 0.5 mm. in diameter and are a convenient standard for comparison.

When areas are magnified 1,000 diameters a satisfactory standard is almost impossible. The dimensions of the original object or area represented are so small that the millimeter becomes an inconvenient unit and the micron—a microscopic unit, the 1/1000 part of a millimeter—is used instead. At a magnification of 1,000 diameters, any circular area measuring 100 mm., or about 4 inches in diameter, represents an original area 100 microns in diameter. The average diameter of a hair from the human scalp is about one-half of that, or 50 microns. Yet a strip of coal section the thickness of a hair contains a great many objects, as is seen in the illustrations. A hair, then, may be considered a convenient standard, remembering that the average thickness is about 50 microns, or 1/20 of a millimeter, or 1/500 of an inch.

Obviously, extensive areas from a coal section, or larger areas of the sections shown at 10 diameters can not be represented at a magnification of 200 and still less at 1,000 diameters. This may suggest that an adequate idea of the nature of larger sections of coals is not obtained through illustrations representing a small area; experience has shown, however, that many layers of coal are so similar in appearance and composition that photographs taken at certain intervals and showing certain characteristics, give a fair representation of a larger piece of coal or even of the whole bed.

CORRELATION OF CHARACTERS.

Before discussing the detailed examination of the coal sections at a higher magnification it will be necessary to correlate the appearance of the features seen in opaque sections or polished surfaces cut vertically to the bedding planes and examined by oblique illumination, with the same features as seen in thin sections examined by transmitted light at the same magnification, or at a slightly higher magnification.

COAL FROM THE PITTSBURGH SEAM.

Compare the opaque cross sections of the coal from the Oak mine in the Pittsburgh bed, Plates XXXVII–XLI, already mentioned, with the illustrations of sections, from the same samples and horizons, prepared from thin sections by means of transmitted light, Plate XXXVII with Plate XLIV, *A* and *B;* Plate XXXVIII with Plate XLV, *A* and *B;* Plate XXXIX with Plate XLVI, *A* and *B;* Plate XL with Plate XLVII, *A* and *B;* Plate XLI with Plate XLVIII, *A*.

In the former illustrations the attritus appears as gray or white laminæ intercalated by darker striæ of anthraxylon. In the latter illustrations the anthraxylon appears as lighter, homogenous strips, and the attritus as the darker portions with a sprinkling or mottling of lighter inclusions. The order is, therefore, partly reversed.

The object of these latter illustrations is to serve as a stepping-stone from the lower to the higher magnifications, and to convey a more accurate concept of the proportion, arrangement, and relationship of the anthraxylon to the attritus utterly impossible to obtain from the illustrations at higher magnifications. A close study of the illustrations at low magnifications and those of coal in the block is essential for this purpose. On the other hand, many details can be seen only in illustrations at higher magnifications.

Compare Plate XLIV, *A* and *B*, magnified 10 and 20 times, respectively, with Plate XLVIII, *B*, magnified 200 times, both prepared from the same section although not from the same areas in the

section, representing areas of "dull coal." The two lighter areas 1–a and 3–a (Pl. XLVIII, *B*), correspond to the lighter strips seen in Plate XLIV, *A* and *B*, but more highly magnified, and the two darker areas, 2–d and 4–d, correspond to the darker portions interlined by the lighter strips more highly magnified. The lighter parts, 1–a and 3–a, show plant or woody structure, with characteristic resinous inclusions, and are anthraxylon; the darker areas plainly are a conglomeration of various microscopic bodies defined later, and are the attritus.

Plates XLIX, *A* and XLIX, *B* (magnified 200 times), are more highly magnified areas included in Plate XLIV, *A*. Plate XLIX, *A*, represents a number of thin anthraxylon components closely piled one on the other. 1–r is a resinous layer, the cell walls of the tissue that once contained the resinous matter having largely disappeared. The area 2–a is a continuation of the resinous anthroxylon; the cell walls have been very much flattened and closely pressed together, so that they are barely recognizable; 3–a is a strip in which the structure is better preserved with resinous and cuticular inclusions; 4–a is a strip of numerous thin anthraxylon components. Below this, at 5–d, is a strip of carbonaceous attritus including spore-exines and resinous bodies; and at 6–a is a thin anthraxylous strip in which the cell structure is faintly visible.

Plate XLIX, *B* (magnified 200 times), represents a more resinous débris in the section shown in Plate XLIV, *A*; 1–d is a sheet of attritus composed chiefly of resinous particles represented by larger oval bodies; more or less irregular small narrow patches of humic matter in gray that are spore-exines; and a dark groundmass consisting of earthy and carbonaceous matter. The strips 2–a and 4–a are thin pieces of anthraxylon. Included between the latter is 3–d, a lamina of attritus containing a large proportion of matter derived from cellulosic plant substances, which are dark red in the section and hence photograph black. In 5–a, a lamina of attritus, very thin anthraxylon strips, and several carbonaceous bodies are included; 6–a is a resinous anthraxylous strip; and 7–a is attritus containing a large proportion of matter derived from woody products which we shall term humic, as well as the resinous matter, earthy matter, and exines, such as are in the other layers of attritus.

Plate LII, *A* (magnified 200 times), shows a more highly magnified area included in the upper anthraxylous part of Plate XLV, *A* (magnified 10 times), with which it should be compared. Although it represents an anthraxylon area, it is readily seen to be composed of several laminæ. The anthraxylon laminæ 1–a, 3–a, and 6–a, alternate with the laminæ of attritus 2–d, and 4–d. The heavy double white lines at 5–c represent cuticles. The lower part of the section is also composed of alternating thin strips of attritus and

anthraxylon; the strip at 7–d being a humic attritus. The cell structure, although recognizable in most parts of the anthraxylon components, is on the whole not clearly distinguishable, except under the microscope where cell structure is easily distinguished in any section examined. At 6–a the remains of the special thickenings of the cells (the checkered part) are clearly shown.

Plate LII, *B* (magnified 200 times), represents a more highly magnified area from the middle region of Plate XLV, *A*. This area is composed largely of attritus, including numerous anthraxylon strips. The larger darker patches, particularly noticeable at the level 2–d, represents more highly carbonized particles, dark red under the microscope. (See chapter on Carbonaceous matter, p. 76.)

Plate LIII, *A*, represents a more highly magnified area in the lower part of Plate XLIV, *A*. The two strips 1–a and 3–a represent thin strips of anthraxylon, the small, white, irregular patches represent for the most part spore-exines, the gray areas represent cellulosic decomposition products, and the black represent the more highly carbonized particles.

Plate LIII, *B*, is an area in Plate LIII, *A*, magnified 1,000 times. The spore-exines, shown in cross section in the latter, are shown here in better detail. The other components, chiefly of cellulosic decomposition products and carbonaceous particles, are underexposed and are not shown clearly, although under the microscope they show up very clearly as will be seen in other photographs.

Plate LV, *A* and *B* (magnified 200 times), represents areas in the section shown in Plate XLVI, *A* (magnified 10 times).

Plate LV, *A*, is mainly a woody layer, with a strip of attritus above and below it. The cell structure is clearly seen.

Plate LV, *B*, shows more definitely the alternation of the anthraxylon with the attritus. The anthraxylon strips 1–a and 3–a correspond to the lighter strips or bands in Plate XLVI, *A*, and the darker areas of attritus, 2–d and 4–d, correspond to the darker strips. The strip 2–d contains a large proportion of carbonaceous matter, and 4–d contains much cellulosic degradation or humic matter, besides the relatively few spore-exines shown as small linear white patches, the resinous and carbonaceous matter, and a number of fine strips of anthraxylon.

With Plate XLVII, *A* (magnified 10 times), compare Plate LVI, *A* and *B* (magnified 200 times), prepared from the same section. In Plate XLVII, *A*, as in the other illustrations of this series, the lighter homogeneous parts represent the anthraxylon and the darker or more or less mottled parts represent the attritus, the anthraxylon constituting the larger proportion. In Plate LVI, *A*, 2–a, 4–a, and 5–a, corresponding to the lighter bands, distinctly show cell structure, and hence are anthraxylon components. Between these are

lodged laminæ of attritus corresponding to the darker striæ of Plate XLVII, *A*, composed of various microscopic bodies. Plate LVI, *B*, represents a woody area in which the cell structure is also very well recognizable. The part designated by 1–ad represents a humic attritus, including a number of anthraxylon strips, the cell structure of which is faintly recognizable.

THE BUXTON COAL.

A comparison of the illustrations of Buxton coal at low and high magnifications is of value and interest. Compare Plate CXXI, *B*, prepared from an opaque section of "dull coal" by reflected light, with Plate CXXI, *A*, prepared from a thin section from the same specimen and photographed by means of transmitted light, at the same magnification, the one being the mirror image of the other. The corresponding components may easily be recognized in the two plates. At 1–d is an anthraxylous attritus with a sprinkling of spore-exines, at 2–s are included a number of sporangia filled with spores. Detailed illustrations of a similar sporangium, at higher magnifications are shown in Plates CXXXIII and CXXXIV. At 3–a is anthraxylon; below it, at 4–sp is a layer of attritus including a number of megaspore-exines and at 5–c is part of a cuticle. At 7–a is an anthraxylon layer. With these also compare Plate CXXII, *A*, in which the same kind of components may be recognized. These illustrations should now be compared with the series at 200 and 1,000 diameters taken from the section represented in Plate CXXI, *A*, and others from the same coal, which show the nature of the coal and the components in detail.

THE VANDALIA COAL.

Compare Plate CXLIII, *A* and *B*, prepared from thin sections at a magnification of about 10 diameters, with the series (Plates CXLVI–CL) at higher magnifications, showing the nature of the component of the Vandalia coal in detail. As has already been shown, the coal from the Vandalia mine is made up of numerous thin, flat, woody or anthraxylon components interlayered with a comparatively small amount of attritus. Compare these also with Plates CXLIV and CXLV, *A* and *B*, representing a horizontal cleavage plane from the same coal.

THE COMPONENTS EXAMINED AT HIGHER MAGNIFICATIONS.

Sufficient proof has been furnished that the so-called bright coal, glanz coal, humus coal, jet coal, bright laminæ, or by what other name it may have been called, represents inclusions of individual components of coal that at one time were larger pieces of wood or

parts of stems or logs. Sufficient proof has also been furnished that the so-called dull coal, matt coal, or canneloid coal, consists of a general débris composed for the most part of small components of greatly varying sizes—at one time small particles or chips of wood—embedded in a mass of microscopic matter, termed attritus, which is derived from a variety of plant parts or plant organs. These kinds of coal, and their components are now presented in detail. Attention is called again to the fact that the woody or anthraxylon components, no matter of what magnitude, were at one time definite fragments, or units, and although they may seem intimately united with one another, or intimately packed or embedded in macerated matter in the coal, they are definite units or components.

THE BRIGHT COAL OR THE LARGER ANTHRAXYLON COMPONENTS.

VERTICAL SECTIONS.

Thin sections have been prepared and examined from many of the thicker anthraxylon components, of all the coals of the present series. In every section examined the anthraxylon components were seen to be derived from the woody part of some plant, of which the cell structure, or the wood fibers were in so fair a state of preservation as to leave no doubt of their origin and identity. In some sections this structure was almost as well preserved as in sound wood, except that the cells or fibers had collapsed as shown in Plate CII, *B*, and CVII, *A* and *B*; in others very careful observation was required to see the structure. (Pl. XCI, *A* and Pl. XCIII, *B*; 1–a.) Between these two extremes all possible intergrades of preservation were found, but in no section had the structure been so far effaced as to be unrecognizable. The state of preservation is never the same throughout the section, as can readily be seen from a study of the photographs; in some parts the cells are almost completely preserved, whereas a little distance away the structure is recognizable only faintly.

Occasional cells or fibers have retained their original form and arrangement quite well, although the walls have been pressed together and the lumina have disappeared, as shown in Plate CVII, *A*, taken from the Royalton coal; often the arrangements of the fibers is much disturbed, although preservation of their form is good, as shown in Plate CII, *B*, taken from the coal from Sesser, Ill. In other sections the fibers are so flattened as to be very thin and rather broad, this probably being the most common condition. (See Pl. XCII, *A* and *B*, from the Ziegler coal.) Some of the walls have become very thin and are intimately united so that the individual cells are recognized with great difficulty, as seen in the

anthraxylon strips shown in Plate XCIII, *B*, taken from the Ziegler coal, and Plate CXLVI, *A*, taken from the Vandalia coal, a condition particularly common in the latter. Plate CI, *A*, taken from the coal from Sesser, Ill., and Plate CXIV, *A*, from the Shelbyville coal, represent structures that contain a varying amount of resinous matter in the lumina of the fibers, common in every coal examined. These resinous contents having retained more or less of their original volume and shape, have kept the cell walls distended to the extent of their volume. The walls themselves show the same effect of decay as in other sections, as is shown in the places where the resinous contents are absent or scarce. (Pl. CI, *B*; Pl. CII, *A*; and Pl. CXIV, *B*.)

HORIZONTAL SECTIONS.

The plant structure is particularly well shown in sections cut parallel to the bedding planes. The reader has become aware, through the examination of the sections cut perpendicularly to the bedding planes, that all the plant cells and fibers have been compressed and flattened, and that the cells and fibers thus flattened lie roughly parallel to the bedding. Therefore, when an anthraxylon component is cut parallel to the bedding plane, all cells lying in that plane are exposed on their broad sides, and if any cell characters are present, such as bordered pits, spiral, trabecular, and scalariform thickenings, they are likewise exposed for examination on their broad side. Also, the original nature of the tissues, such as the xylon strands separated by cortex, vascular strands in the cortex, rays, and even leaf traces, may be detected. Thus much of the anatomy of the plants contributing to the coal may be seen.

PRESERVATION OF STRUCTURE.

Some part of a coal bed contains more anthraxylon coal with better preserved cell structure than others, and some coal beds contain more of the better preserved anthraxylon components than others. For example, of the coals examined that from Carbon Hill, Ala., contains the most and the best preserved plant structure.

The coal of the Pittsburgh bed seemingly ranks next, but its structure and cell preservation differ in various localities and at different horizons in the bed. The coal from the experimental mine, Bruceton, Pa., has revealed the most and the best preserved structure and that from Madison, Pa., the least of all the coals examined in this seam.

At one place in the bed the structure of different layers may vary. In the Oak mine, for example, the cell structure is better preserved at the top than at the bottom. The same is true of the structure of the smaller components, as a close examination of the illustrations of the coals from that mine will show.

The coal from the Vandalia mine, near Terre Haute, Ind., the most anthraxylous of all the coals examined, has retained the least plant structure. This coal reveals an abundance of structure quite difficult to see in certain parts of some cross sections, but easily observable in horizontal sections in the anthraxylon matter.

As woody structure has been seen in all coals examined there can be no doubt that almost all of that portion in coal that has been termed "bright coal," "glanz coal," or "jet coal" is derived from components that at one time were pieces of wood. What kind of wood or what kind of trees they represent does not concern this report any more than how large a part of a certain tree, stem or branch any of the components represents, for there was no opportunity to study this comprehensively.

THE "DULL COAL."

In preceding chapters the "dull coal" has been shown to consist largely of smaller anthraxylon components embedded in a mass or matrix composed of more finely divided plant matter called the attritus. The "dull coal" may conveniently be classified into two main subclasses—the *smaller anthraxlyon components* and their embedding matrix, the *attritus*.

THE SMALLER ANTHRAXYLON COMPONENTS.

The appearance of the smaller anthraxylon constituents in the block and in the section at low magnifications has already been pointed out. Their appearances at low and at high magnifications have been correlated. The anthraxylon inclusions seen in cross sections and the patches usually showing a woody structure seen in horizontal cleavage fractures have been shown to be identical. Through a correlation of the cross sections and the horizontal fractures the form, thickness and sizes of the anthraxylon parts have been learned, as well as their distribution and the proportion of their mass to that of the other components. Their origin and mode of formation have been indicated through analogous formations in peat. Their structure and appearance at higher magnifications remain to be shown. The anthraxylon components differ greatly in size, ranging down to microscopic bits.

SIZE AND FORM.

To obtain a correct idea of the relative as well as the actual thickness of the anthraxylon components, the reader should study carefully all the photographs prepared from opaque sections at a low magnification with those prepared at low magnifications from thin sections by means of transmitted light. The latter are of particular interest in connection with this study and should be correlated with

the appearance of the coal in horizontal cleavage surfaces. Plates XLIV to XLVII and Plate XLVIII, *A* (magnified 10 times) give an excellent idea of the relative thickness, arrangement and mode of compilation in most of the ordinary coals. Plate CXLIII, *A* and *B*, is a good representation of a very anthraxylous coal. With these should be correlated the photographs at higher magnifications. (Pls. XLIX–LIX and Pl. CXLVI, *A* and *B*.)

Plate XLVIII, *B*, prepared from the same sections as Plate XLIV, *A* and *B*, gives a definite idea of the thickness of some of the anthraxylon components. The relatively thick band 3–a, running lengthwise through Plate XLVIII, *B*, is approximately 32 mm. thick in the photograph, and therefore was actually only a very little more than one-sixth of a millimeter; 1–a and 3–a in Plate LV, *B*, both relatively thick pieces, were only one-tenth and one-fortieth of a millimeter thick. In the same photograph at 4–d several strips are embedded that were only about one one-hundredth mm. thick. Similarly the strips in photographs representing coals from other localities in the Pittsburgh bed, as, for example, Plates LXIII to LXVI, and Plate LXIX, *A*, some of which show their cell structure clearly, are extremely thin, but nevertheless they were at one time chips of wood similar to those found in the peat of to-day.

The reader can calculate for himself the actual thickness of any of the anthraxylon strips represented by measuring the thickness of the strip in the photographs prepared from the cross sections of any coal and dividing that measurement by 200 for photographs at a magnification of 200 and by 1,000 for those at a magnification of 1,000. The study of the photographs of horizontal cleavage surfaces, together with those of cross sections at a low magnification, gives a better idea of the actual width and length of the anthraxylon components.

A considerable part of the anthraxylon matter is chopped up or granulated, although much of this has also been flattened and some is angular and more or less isodiametric. This form consists of extremely small particles varying from colloidal size to whole cells and is a part of the attritus called humic matter. The proportion of this class of anthraxylon or humic matter varies from layer to layer, and from bed to bed as shown in LI, *A* and *B;* LII, *B;* LIV, *B;* LV, *B;* LVIII, *A;* LXI, *A* and *B;* LXII, *A;* LXIII; LXVI; LXVIII; LXX, *A* and *B;* LXXI, *A;* LXXII, *A;* LXXIV, *A* and *B;* LXXVI, *A* and *B;* LXXXIV; LXXXVI; LXXXVIII, *A;* LXXXIX, *A;* CIV, *A;* CIX, *A* and *B*. It is better shown in sections cut horizontal to the bedding, and is discussed under the attritus as humic matter.

A comparatively small amount of anthraxylon matter is amorphous. From the standpoint of a microscopist there are, strictly

speaking, no homogeneous substances found in organic substances in coal. Even the cell walls of the anthraxylon resolve into individual particles or micelli when examined by ultra-microscopic means. Anthraxylon or humic matter in this finely divided condition is said to be homogeneous. Such matter sometimes forms the embedding medium of many kinds of finely divided particles, forming the groundmass, which has a granular and amorphous appearance. This phase is discussed in relationship of coal at high magnification, under the head of attritus.

DISTRIBUTION.

Although, in most coals, such as the Pittsburgh coals, the anthraxylon chips are embedded in an attritus, the pieces may be packed more or less immediately one on top of the other. This is true to a larger extent of the Illinois and Indiana coals examined. In the coal from the Vandalia mine, near Terre Haute, Ind. (Pl. CXLIII, *A* and *B*), the larger part of the coal, by far, is composed of such chips lying directly one upon the other with comparatively little of the attritus interlayered between them.

COLOR AND TRANSPARENCY.

The color of the anthraxylon varies from dark red to light yellow in thin sections, depending on the thickness and transparency of the section. Other factors being equal the thinner the section, the lighter the color; the thicker the section, the deeper the color. Sections of equal thickness but from different samples from the same or different beds also vary in transparency; the more transparent, the lighter the color, and the less transparent, the darker the color, it ranges from a yellow to a deep red.

Of the coals examined, the anthraxylon of that from the Vandalia mine, near Terre Haute, Ind., is the most transparent, although different sections taken from the same coal may vary in this respect. That of the coal from the Zeigler mine is, in general, less transparent than those examined from the surrounding fields. The anthraxylon components from the Pittsburgh seam varies according to the locality from which they are taken. That from the experimental mine and from the Oak mine are relatively transparent and light in color; that from Madison is considerably less transparent and of a deeper red color, while that from the Connellsville region is the least transparent and of a deep red color.

The transparency of anthraxylon depends on its carbon content. Roughly, the transparency of the coal varies inversely with the carbon contents. No anthraxylon components of the coals examined were absolutely opaque, and only a few were barely translucent in thin sections.

REMAINING PLANT STRUCTURE.

The anthraxylon components may almost always be recognized readily by their color, and by their peculiar physical structure, due to the original cell structure of the material from which they are formed. This is either definite cell structure, similar to that seen in living plants, as seen in Plates XVI, *A*; LVII, *B*; LXVIII; LXIX, *A*; LXXXIV; LXXXV; LXXXVII; and CXIV, *A*, or of fine lines more or less parallel to each other, as seen best in Plates LVII, *A* and *B*; LXIII; LXIV; LXV; XCI, *B*; XCII, *A* and *B*; XCIV, *A*; and CIX, *A* and *B*. These lines have resulted from the collapsed, compressed, and intimately united condition of the original cell walls of the plant from which they are derived. Between these two extremes all possible states of preservation may be observed.

In the vertical sections the cell structure of the smaller chips usually does not seem to be so well preserved as in that of the larger pieces; however, many strips are found in which the structure is about as well preserved as in living plants. Examples are shown in Plates LXIX, *A*; LXXXIV, LXXXV; and LXXXVII. Such preservation is by no means rare, yet considering the total anthraxylon mass, which constitutes by far the largest part of the coal, it is the exception rather than the rule. Another very common peculiarity of structure that is easily recognized is where the cell walls, although collapsed, have retained a relatively large part of their original mass, and have either been flattened out or variously folded and contorted. This is not nearly so well preserved as in the previous examples. Such structure is shown in Plates XLVIII, *B*; LV, *A* and LIX, *A*.

Attention is called to the fact that the structure of the wood fibers can be shown distinctly only when cut more or less at right angles to the fibers. When cut approximately parallel the structure is not easily recognizable as it is normally so poorly preserved. Plate LVII, *B*, Plate LVIII, *A* and *B*, and Plate C, *B* show more or less parallel sections. As the anthraxylon fibers lie in every conceivable horizontal direction, the chances are that only a small number of the fibers are cut more or less at right angles in the vertical sections, and hence the majority, even if well preserved, will escape notice, other good examples are shown in Plates LII, *A*; LV, *A*, 3–a; LXIV; XCII, *B*, 1–a.

The most common structure is that in which the original cells have been so much flattened and pressed together that they are difficult to recognize. Such structure may be seen in almost every section from every coal examined. See many of the photographs representing anthraxylon coal, particularly those of the Zeigler, Buxton, and Vandalia coals. In a few photographs there appears at first sight to be no structure. An example is shown in Plate CIX, *A*

(magnified 200 times). But when such sections are put under higher magnifications with proper illumination the structure is clearly seen, as is shown in Plate CIX, *B* (magnified 1,000 times), prepared from the same section as was Plate CIX, *A*. Plate CIV, *B*, and Plate CV, *A*, magnified 1,000 times and 200 times respectively, reveal the same fact. Again, in Plate LXXXIX, *A*, are several anthraxylon chips in which very little structure can be detected; but Plate LXXXIX, *B*, taken from the same area, but magnified 1,000 times, leaves no doubt as to the remaining cell structure. At low magnifications the Vandalia coal (Pls. CXLVI–CL) reveals very little cell structure in the anthraxylon components, but when the sections are examined under high power and proper illumination, the remaining structure is well shown. This is seen more decidedly in horizontal sections discussed later.

Frequently where the structure is not easily recognizable, the mass and the form of the cell have not been destroyed so much as the features or qualities that differentiate the cells from one another. The cell walls, or fiber walls, have been rendered more homogeneous during the processes of coal formation. The middle lamellæ having disappeared, the cell walls and the lumina, which have completely collapsed, have been so intimately united that the whole cell is a complex, seemingly homogeneous mass. The individual cell walls of such a homogeneous anthraxylon mass need not necessarily be thin, but may be of the same thickness as those more easily distinguishable. These cells can be distinguished only through special illumination, by taking advantage of the slight differences of the refraction of the different parts of the walls, or by means of polarized light, as each fiber or cell is optically active. These cells or fibers have not been obliterated, but the characteristics or qualities through which they are normally distinguishable, have been more or less removed.

STRUCTURE SEEN IN HORIZONTAL SECTIONS.

The clearest evidence of the cell structure is obtained in horizontal sections which not only verify the interpretations made from the vertical sections, but also amplify and bring out the characteristics in greater detail and clarity, and expose other characteristics that are not observable in the vertical sections.

The true nature of the larger and the thinner chips, such as are characteristic of the horizontal cleavage surface, is disclosed, and also that of the scattered fibers or small complex of fibers and other comminuted plant matter. The nature of the original tissues may often be recognized distinctly. The structures or form of the cells and fibers, whether long, short, thin, thick, rounded, or isodiametric, are plainly shown. The cell character, such as pittings and spiral

trabecular and scalariform thickenings, rarely seen in the vertical sections, is shown in almost every horizontal section. In some sections, as in Plate CXL, *A* and *B*, remainders of the nuclei are apparently recognizable. Parts of plant organs, like sporangia, leaf traces, vascular strands, petioles, and other parts of leaves may be observed, often in a remarkably good state of preservation.

The photographs prepared from horizontal sections are for the most part self-explanatory, yet it may be well to call attention to some of the principal features illustrated.

As the object of the photographs taken from the horizontal sections is to show some special characteristic rather than the anthraxylon chips and their structure, these photographs present, in the main, parts of coal that lie between the chips, and most of them show only the edges or fringes or cut parts of the more solid chips. A relatively small anthraxylon chip magnified 200 diameters would make a photograph many times the area of a page in this bulletin. One of the characteristic chips or patches shown in Plate XXV, if only one-fourth inch, or about 6 mm., square would if magnified 100 times cover a space of 25 inches square. Only a few of the photographs from horizontal sections are therefore wholly, or in part, intended to illustrate solid woody components or chips.

Plate LXII, *A*, of the constituents of the attritus in horizontal sections shows on the lower right-hand corner a part of an anthraxylon chip in which the cell structure is well defined. Plate LXXIV, *A*, a horizontal section from the coal of the experimental mine, magnified 150 diameters, shows the anthraxylon matter in a rather comminuted condition and consisting mainly of separated fibers and cells.

Plate LXXIII, B, shows, besides the part of a sporangium in the middle, much anthraxylon matter in which the structure is also clearly shown, particularly in the lower part. Plate LXXI represents much of the anthraxylon matter in a comminuted condition, but also parts of the more solid chips that have retained some of the original structure in fairly good condition. Plate LXXII, *A*, represents a strip of anthraxylon embedded in the attritus in which the spiral thickenings of the wood fibers are still recognizable. In Plate LXXII, *B*, the section cuts obliquely through overlapping anthraxylon chips containing spiral vessels. A leaf-trace, in which the remains of spiral vessels are clearly seen, lies between the two. The cell characters of the piece in the lower right-hand part of the photograph are shown, also the cells of the piece represented in the left-hand part of the photograph are cut diagonally, and are not so clear as the former. In the extreme upper part another chip is seen with scalariform thickenings. On the right-hand side of Plate XCIX, *B*, from the Zeigler coal, is shown part of a solid, narrow-

fibered chip without cell thickenings. Through this section of the chip may be seen the general débris lying under it. The components of the dèbris or parts of other chips are commonly seen under an anthraxylon chip, showing how exceedingly thin these chips may be.

Plate CXL, *A* and *B*, and Plate CXLI, *A*, from the Sipsey coal, show horizontal sections of a tissue in which the cells are remarkably well preserved. The cells seem to have been more or less isodiametric, and the structures within them very strongly resemble nuclei. They would certainly be called nuclei if seen in a section from a living plant; not only that, but the darker granules seen in the nuclei-like structures would also be called chromosomes. Whether they are actually remains of the nuclei and their chromosomes must remain an open question, as the preservation of such delicate cell parts seems doubtful. Detection of many similar objects are necessary for a positive decision.

Plate CXLI, *A*, shows tissues with large isodiametric cells in the lower part, and large fibers with multiseriate bordered pits, characteristic of the Cycadofilicales and common in many coals.

Plate CXXVIII, *A* and *B*, represents parts of an anthraxylon chip from the Buxton coal. Although the chip is not well preserved, the structure of the tissue is distinct. The diameters of all the cells are large. In the section may be seen a series of large tracheæ with bordered pits, separated by short parenchymatous cells, which show vaguely in the photograph. These and other features leave no doubt that the tissue is derived from one of the Sphenophyllæ. In the Buxton coal the woody structures are difficult to detect in cross sections, but an examination of the photographs just mentioned leaves no doubt that the Buxton coal has retained its share of woody structure, though this is not so well preserved as in most coals.

In the coal from the Vandalia mine, the woody structure is preserved the least, and examination through cross sections alone would lead to the conclusion that very little structure remained. But when this coal is examined in horizontal sections, an abundance of structure is seen to have persisted, although it is rather poorly preserved. A horizontal section of coal from the Vandalia mine when viewed at a low magnification, as shown in Plate CXLIV, *A* and *B*, leaves no doubt as to the presence of much woody structure. This is much more clearly shown at higher magnifications, as in Plate CXLV, *A* and *B*, in which both scattered as well as solid tissues appear. Although the cell structure of this coal is poorly preserved, such characters as spiral and scalariform thickenings are not rare in the horizontal thin sections.

REDUCTION IN THICKNESS FROM THE ORIGINAL OF THE ANTHRAXYLON.

A general estimate of the reduction in thickness of the woody components in coal is difficult to obtain, because usually the fibers are not

easy to distinguish from one another when they have been much compressed and intimately united, and because the amount of reduction in thickness varies greatly in the same piece as well as in different pieces. However, in many sections definite counts and measurements can be made.

The amount of reduction in thickness may be realized in examining thin horizontal sections in which frequently several fibers may be seen lying one above the other, all in focus at a low magnification. In focusing up and down under a high magnification a number of fibers may be recognized in a comparatively small space. These must have been compressed a great deal. Many components, however, have retained half or more of their original thickness.

Counts made in a thin section from the Ziegler coal at a magnification of approximately 1,000 diameters gave 40 lines per 50 microns in an anthraxylon lamina 500 microns or 0.5 mm. thick. Assuming that every line under observation represents a woody fiber, the whole piece would have 400 fibers one above the other, or 800 cells to the millimeter. Assuming that the average diameter of the cell originally was 50 microns, the original thickness of the chip would have been 20 mm. This piece in question, therefore, suffered a reduction to one-fortieth of its original thickness. This is an extremely large reduction, although by no means uncommon.

Plate CII, *B*, represents part of a thick anthraxylon component from the Sesser coal containing approximately 240 cells to the millimeter. A few well-preserved cells remaining in it have an average diameter of 25 microns. Assuming this to be the average original diameter of the cells of the piece in question, it would have suffered a reduction to only one-sixth of the original thickness. Structures in the state of preservation as shown in Plate CII, *B*, are common. This reduction in thickness does not indicate a loss in the mass in the same proportion, because the collapse of the cell walls alone—that is, the removal of the air space of the lumina—will account for a large part of the reduction, the amount depending on the size of the lumina or, in other words, on the thickness of the walls. The cells in the anthraxylon piece in Plate CVII, *A*, from the Royalton coal, have been compressed to not more than one-half of their original thickness in the upper part of the photograph at 1–a to 3–a. In the lower part of the photograph, at 4–a, they are reduced considerably more. An average of 175 cells to the millimeter for the lower part compared to 80 cells to the millimeter in the upper part was estimated. The reduction of the cells in the lower part has therefore been to between one-fourth to one-fifth of their original thickness, the average diameter of the fibers being 25 microns. Most of the cells of this large anthraxylon component are in the state of preservation shown in the lower part of the photo-

graph, an average condition of all the larger anthraxylon components in this coal. The smaller fragments as a rule have been reduced much more in thickness than the larger ones, but not to less than one-fortieth of the original thickness.

In the coal from the Pittsburgh bed the cells, in general, have been reduced more toward the top than at the bottom of the bed. An average anthraxylon component approximately 0.2 mm. thick, and hence one of the thinner chips, was found cut squarely across the grain and hence suitable for making counts. The average number of cells one above the other in this piece was 50, hence there were 250 cells to the millimeter of coal. The original diameter of the cells according to various measurements and estimates can not have been over 50 microns (0.05 mm.) nor much less, 50 microns being probably very nearly the average diameter of the original cell. On the assumption that the original diameter was 50 microns, the original thickness of the piece in question would have been 2.5 mm., a reduction in thickness therefor of 12½ to 1. In this piece the cell walls can not have lost much of their original thickness or mass.

Plate LIX, *B*, from the Oak mine, shows a type of wood and a mode of preservation common not only in this coal but in all coals examined. The average number of cells to the millimeter is 368. The average diameter of the cells of this type is about 30 microns. The reduction in thickness has been 11 to 1 or 10 to 1.

To go into further detail is unnecessary, as a number of other counts give similar results. The diameters of a considerable number of wood fibers well enough preserved to be reliably measured varied from 50 microns to 25 microns. The diameters of a number of carbonized cells measured between 30 and 35 microns. Therefore, from 25 to 50 microns may be relied upon as the approximate thickness of these wood fibers.

The thicker anthraxylon components evidently have not been reduced in thickness as much as the thinner ones, and in general the thinner the component the more have the cells been reduced. In other words, the greater the maceration the greater has been the loss of the cell mass.

These few measurements indicate progress toward definite determination of the amount of compression and reduction of volume in the change from peat to coal, but more extensive measurements are required to make safe conclusions. However a definite conclusion in this much-discussed problem, is now more possible than it has been in the past.

RESINOUS INCLUSIONS.

Many of the anthraxylon components contain inclusions similar to those found in Tertiary and Cretaceous lignites. In these lignites the woody coal usually has been preserved so well that the genera and

in some specimens, species can be determined, and the structure is closely related to that of living species. Almost all the parts of stems thus identified have proved to be those of conifers whose anatomy is well known, and wherever inclusions were found in the lignites they proved to be the natural resins of the plant.[a] The assumption is fair that similar inclusions found in bituminous coals, in those parts derived from the woody parts of plants and retaining the original cell structure, are also natural resins and represent material, more or less changed, secreted by the plant when living. Such resinous inclusions in anthraxylon matter are abundant in all the Paleozoic bituminous coals that have been examined. Some coals, as that from the Vandalia mine and the Buxton mine, contain a considerable proportion of such anthraxylon matter, others comparatively little. The percentage on the whole is small.

There are clearly two types of resinous matters, and each is included in a different kind of woody structure. The one is always sharply differentiated from all other resin-bearing matter, both in that the anthraxylon including the resinous matter is of a lighter color, always of the same type of structure, and the resinous matter is always of a light, clear, yellow color, easily distinguished in the coal. This type is shown in Plate LIX, *B*, from the Oak mine; Plate CI, *A* and *B*, and Plate CII, *A*, from the Sesser coal, and Plate CXIV, *A* and *B*, from the Shelbyville coal. This type constitutes an appreciable part of all coals examined and has the same appearance in all of them.

The tissues that include this type of resinous matter appear to be those of Gymnosperms, but they have not been examined sufficiently to draw a positive conclusion. Wherever this type of anthraxylon is found it shows definite bands with better preserved cell structure and larger resin contents, alternating with bands in which the cell structure is not so well preserved and in which the cell contents are either empty or small, and it clearly resembles annual growth rings in living trees. In a number of specimens examined, a series of cells with the thickened cell walls lie just below or within the tier of cells containing the most resinous matter, as seen in Plate CI, *A* and *B*, Plate CII, *A*, and Plate CXIV, *A* and *B*.

The resinous matter, according to the amount contained in the cells, has assumed shapes in cross section from oval or almost circular, where the cells originally were filled, through lenticular shapes to filar in which the cells originally must have been almost empty. The cells have collapsed to the extent permitted by their contents; some of the cells that have collapsed completely contain no resinous matter, as is well illustrated in the photographs referred to in the

[a] White, David, and Thiessen, Reinhardt, Origin of coal: Bull. 38, Bureau of Mines, 1914, 390 pp.

preceding paragraph. This type of resinous matter contains no bubbles or vacuoles so common in the other type. The mass is completely homogeneous as far as can be determined by means of highest powered lenses; that is, no granules, common in the woody matter in coal, can be detected. The lines or other abrasions seen in the photographs are mostly due to marring of the sections in cutting them.

The second and commoner type of resinous matter probably is derived from several kinds of plants as their sources. A number of recurring types of structure are recognized, each one including a different type of resinous matter. These resinous contents differ from one another more in size and form than in color or any other physical character. In color, consistency, and transparency they are similar to each other and also to the tissue including them, so that often they are not easily distinguished from the tissues. Many contain vacuoles or bubbles of greatly varying sizes, which when present afford a sure sign for their recognition; others contain lines of refraction, very irregular canals, or signs of apparent breakdown or granulations. Aside from these inclusions, the mass of the particles is usually homogenous or very finely granular, differing markedly from the anthraxylon components, which as a rule are coarsely granular. In certain specimens the particles have unmistakably been found to be void in form. This is clearly shown in Plates CXLVIII to CL, a series from the Vandalia coal.

Characteristic illustrations of anthraxylon components with resinous inclusions are seen in Plate XLVIII, *B*; Plate XLIX, *A*; Plate LXIX, *A*; Plate LXXVIII, *A*; and Plate C, *B*.

THE KINDS OF TISSUES REPRESENTED IN THE COALS.

An examination of sections from a number of coals, as those in the illustrations presented, shows that by far the larger proportion of the tissues remaining represent woody parts of plants; that is, parts of stems, branches, twigs, and roots, including all the tissues, except the bark, that goes to make up such a part of the tree or shrub. It can not be said with certainty that bark has contributed appreciably to the constituents in question. If bark is present at all in coal it finds its recognition possibly in components that seem wholly different, a point to be discussed later.

The anthraxylon of the dull coal, then, is derived for the most part from rather small chips of semidecayed woody tissues, such as are prevalent in many peat bogs of to-day. Prosenchyma, or wood proper, and parenchma, such as cortex, pith, and rays, are all found and are clearly distinguishable. Nevertheless there is no doubt that some of the structure seen in thin sections is derived from the more succulent or younger parts of plants, some of which are herbaceous.

Leaf strands, with some of the accompanying tissues, petioles, and other vascular strands are frequently detected. What seem to be delicate tissues of plants are frequently seen, as in Plate LXXIII, *A*, which is a section of the Pittsburgh coal. The parenchyma of leaves is rarely observed, yet occasionally structures are seen that might be construed as having been derived from leaf parenchyma, and some structures represent unmistakably leaf tissues. In Plate CXX all the leaf tissues, particularly the palisade cells, are well represented. Compare the leaf tissues of a living Cycad, shown in Plate IX, *A*. Usually the matter contained between leaf cuticles has disintegrated beyond identification.

CUTICLES.

In all leaves, petioles, green parts, young stems, twigs, fruit, and seeds of plants the outermost layer of tissue consists of tabular cells that are closely united and are uninterrupted except by stomatal pores. This layer is the epidermis. In some plants this layer persists with little change; in others it is thrown off sooner or later and replaced by a layer of cork.

The exposed surface of all epidermal cells are covered with a layer of cutin forming a continuous transparent film or membrane over the entire surface of leaf or stem. This film is called the cuticle. (See Pl. IX, *A* and *B*.) It is present on all leaves, petioles, green or young stems, twigs, fruits, berries, and sometimes persists on older stems and branches. In many plants the cuticle is covered with waxy and resinous matter, and in some this matter is abundant enough to have commercial importance, as in the wax palm (*Ceroxylon andicola*) and the bayberry (*Myrica cerifera*). The waxy coatings may form coherent layers or incrustations upon the cuticle; or may consist of vertical rods, of short rods or rounded grains, or of minute grains or needles.

The cuticle resists the action of putrefying organisms and persists under peat-forming conditions after most of the underlying tissues have disintegrated or have disappeared. Cuticles or fragments of cuticles are always present in peat, occasionally in large proportions.

CUTICLES IN COAL.

Similarly in coals a large amount of cuticular matter and some cuticularized tissues have survived and are present, often forming appreciable proportions of the "dull coal." (Pls. XXIV, *A*, and XCVIII, *A* and *B*.)

In thin sections, under the microscope, many cuticles appear as bright golden yellow bands of considerable length and relatively narrow. One edge is usually smooth and the other is usually serrate. Frequently cuticles occur in pairs with the smooth edges toward

each other. In Plate XCVIII, *A* and *B*, taken from a section containing a large proportion of cuticular matter much like that shown in Plate XXIV, *A*, the cuticles are represented by light-colored bands, sometimes in pairs, embedded in a débris derived largely from leaves and other vegetable matter. Cuticular matter is also present in coals in a macerated or more or less fragmented condition. In this condition it forms a constituent of the attritus, and is often difficultly distinguishable from fragmentary spore-exine matter.

Like the spore-exines the cuticles may be separated easily from the coal by means of Schulze's reagent. When thus separated they appear as tissues or films constructed of cells (Pls. CXIII, *A*, and CXXXVI, 5). They are, however, noncellular, transparent membranes and the apparent cell structure is due to ridges on the under surface that conformed to the once underlying epidermal tissue. A considerable number of patterns of the apparent cell structure, or in other words, different types of cuticles, are present; indicating that a number of different species or genera of plants are involved.

BARK.

Nothing has been observed that could be said with certainty to have been derived from bark. There is, however, a constituent reoccurring in all coals, most frequently in the Pittsburgh coal, that might be interpreted as derived from bark. It is shown in Plate LXXXIII. This component is always dark brown, lumpy, porous, large-meshed, and of irregular structure. By far the largest proportion of this component has retained some of the original plant or cell structure, but this structure is poorly and irregularly preserved, and seems to be derived from large-celled tissues. It almost always includes a large number of resinous appearing globules, and frequently more highly carbonized matter, and parts of the tissue, or strands of tissues, in which the plant structure is well preserved. In some of the components the whole mass is fairly well preserved, but in others the whole mass has disintegrated into irregular fragments, having the same color and general appearance. Frequently the component is composed of bands of tissues alternating with bands of granular, disintegrated matter.

As seen under the microscope the components vary much in size and also in transparency. The most transparent ones are dark brown in thin, but opaque in medium thick sections.

This constituent, possibly derived from bark, is characterized by its brownish red color in thin section, irregular structure, lumpiness, and relative opacity, and it is easily distinguishable from the rest of the coal. Although in some layers or laminæ it may be quite abundant, yet it forms but a small part of all the coal.

THE ATTRITUS.

An examination of the attritus at a magnification of more than 200 diameters shows that it is composed largely of definite units or well-defined particles and contains very little amorphous material. These units, or particles, constituting the attritus consist chiefly of woody degradation products or humic matter, spore exines of a large variety, resinous particles of various origins, particles derived from plant tissues in a more highly carbonized condition or carbonaceous matter, and mineral matter such as pyrite granules and sand. These constituents are present in greatly varying proportions, but the most important are the first three named. Occasionally the carbonaceous matter also becomes predominant.

THE OAK MINE COAL; CROSS SECTIONS.

An examination of some of the illustrations will verify this general statement. Plate LI, *A* (magnified 200 diameters), representing coal from the Oak mine in the Pittsburgh seam, and prepared from the same cross section as Plate XLV, *A* and *B*, represents a portion in cross section of a typical attritus that contains a large proportion of spore exines, shown here as small, irregular white linear patches embedded in a darker groundmass. The mass in which the spore-exines are embedded is shown in detail in Plate LI, *B*, an area included in Plate LI, *A* (magnified 1,000 times). It should be considered that the actual area represented in this photograph is of microscopic size, measuring only about one-tenth of a millimeter, or 100 microns, in diameter. In this photograph the cross sections of the spore-exines are shown as heavy white wavy lines. These represent collapsed spheres with the spore walls pressed together closely; in some the remaining cavity is clearly shown. The wavy or crenulated outline is in this spore is due to serpentine ridges on the surface of the spore wall, better shown by the horizontal sections (Pl. LXI, *B*; Pl. LXXV, *A*; Pl. LXXVI, *A*), and by the isolated spore-exine shown in Plate LXXXII, 1 and 2.

Lodged between the spore-exines are seen degradation products of cellulosic origin, shown in gray, a few resinous particles, also in gray, and darker carbonaceous matter in black. Under the microscope the spore-exines are light-yellow, translucent bodies; the anthraxylon components and other cellulosic degradation products are orange to light red, being similar in color to the larger anthraxylon components; the resinous particles also are of a similar color; the more carbonaceous components appear red to dark red in thin sections, and are opaque in thicker sections. As seen in these and other photographs, much of the anthraxylon matter consists of very fine particles, homogeneous in appearance at magnification of 200 diameters, but resolved into fine particles at 1,000 diameters.

Plate LIII, *A*, taken from an area of the section included in the lower part of Plate XLIV, *A*, shows the relative sizes and proportion of the different components. The attritus is composed largely of spore matter, but also contains some humic matter besides the thin anthraxylon strips running through it; carbonaceous particles of a relatively large size are also numerous. The large number of dark patches represent the more carbonaceous anthraxylon components. These are dark red and almost opaque under the microscope. In thicker sections they are opaque, but in thinner sections they become translucent and have a very dark red color, to which a spectrum or a panchromatic plate is not sensitive, and hence they are represented in black in the photograph. Plate LIII, *B*, represents an area included in Plate LIII, *A*, at a magnification of 1,000 diameters. The spore-exines are in white, the more carbonaceous anthraxylon matter in black, and the general anthraxylon or humic matter and the resinous matter are gray. The attritus does not always contain such a large proportion of spore matter as shown in the foregoing illustrations.

Plate L, *A*, shows a part of a lamina that contains relatively few spore-exines, a large proportion of finely divided anthraxylon particles or humic degradation matter, shown as thin gray objects, resinous matter shown as gray oval or ovoid bodies, and some carbonaceous matter shown as black oval and irregular objects. Plate LIV, *A* and *B*, and Plate LV, *B*, show varying proportions of the constituents of the attritus, but the fact that humic particles, spore-exines, resinous, and carbonaceous matter form the chief constituents in all illustrations should be noticed.

THE EXPERIMENTAL MINE COAL; CROSS SECTIONS.

The coal from the experimental mine, at Bruceton, does not differ materially from that of the Oak mine. As the only coal examined from this mine has been from samples gathered by standard sampling methods, the horizon of the seam that the coal represented is not known. A number of sections have been prepared from such samples, but the differences as seen in these sections have not been greater than are shown in the coal from the Oak mine, in the series taken from top to bottom. The proportion of the attritus to the anthraxylon, as far as can be learned from the sections on hand, and as may be seen from the photographs, is about the same as that in the coal from the Oak mine. The constituents of the attritus are also the same kind as those in the attritus of the Oak mine. Also the relative proportion of each constituent is similar.

Plates LXIII to LXVI represent intervals of a continuous strip of the coal from the experimental mine. The cell structure is apparent everywhere in the anthraxylon matter. Little spore mat-

ter is noticeable in these sections; there is considerable resinous appearing matter, the finer matter interlayered with the fine débris between the anthraxylon strips, and also some highly carbonaceous matter, particularly in Plate LXVI, where it appears as irregular oval granules. Plate LXVII and Plate LXVIII, both from the same section, show considerably more spore matter and macerated matter. The anthraxylon strips 6–a and 8–a in Plate LXVII appear homogeneous in the photograph, but under the microscope, with proper illumination, remains of original structure are clearly seen.

Plate LXIX, *A*, represents a part of a section in which the anthraxylon components with well-preserved cell structure are embedded in a highly carbonaceous attritus. The light-colored lump at 3–d is a mass of closely united spore exines. Plate LXIX, *B*, represents layers rich in spore matter, seen everywhere in this coal. The dark lumps at 2–d and 4–d are resinous appearing, opaque inclusions. Plate LXX, *A* and *B*, represents areas from similar layers shown in Plate LXIX, *B*, at a magnification of approximately 1,000 diameters, and show the nature of the matter in which the spore-exines are embedded. The exines appear to be the same as those seen in the Oak mine coal. Plate LXX, *A* and *B*, shows the various constituents distinctly; the gray humic matter, the dark carbonaceous matter, some of it in very minute particles, the more homogeneous resinous bodies, and the lighter spore matter are all shown as individual particles. Attention is again called to the fact that the original areas represented in Plate LXX, *A* and *B*, are only one-tenth of 1 millimeter in diameter.

THE OAK MINE COAL; HORIZONTAL SECTIONS.

As in examination of the anthraxylon components, sections of the attritus cut parallel to the bedding planes are particularly well suited for the examination of its components. The remaining plant cells of the components of the débris, like the cells of the larger anthraxylon coal, are mostly flattened, lying horizontal with the bedding planes. A section through them, or including them in whole or in part, exposes the larger part or surface to view, and if any characters are retained they are far better visible on the broad sides than on the edges exposed in a cross section. Plate LXI, *A* (magnified 150 times), Plate LXI, *B*, taken from an area included in the former and magnified 1,000 times, Plate LXII, *A* (magnified 150 times), and Plate LXII, *B* (magnified 1,000 times), from an area included in Plate LXII, *A*, are from horizontal sections prepared from the same sample as Plate XLIV, *A*, and Plate XLV, *B*. It must be considered that the photographs represent only a small part of the sections selected from representative areas, and that since the

smaller anthraxylon components are both numerous and as a rule quite closely packed together, a large proportion of any horizontal section is usually occupied by anthraxylon. Plate LXI, *A*, corresponds to a layer of coal similar to that shown in Plate LI, *A*, and presents a large amount of spore matter, represented by the smaller circular to oval white areas, which are spore-exines lying on their broad sides. The irregular gray components among the spore-exines represent the humic matter, and the black irregular parts represent the darker and more opaque or highly carbonized matter. Plate LXI, *B* (magnified 1,000 times), shows in detail the spores, their shapes, surface markings and distribution, and the more carbonaceous or more opaque components. These are embedded in the fine groundmass composed of humic matter, consisting of still more finely divided matter. Plate LXII, *A*, corresponding to a portion of coal shown in cross section in Plate LIV, *A*, shows relatively little spore matter but considerable humic matter and opaque matter, both mineral and carbonaceous. In the lower right-hand part of the photograph is part of an anthraxylon component with the cell structure well preserved. Other small anthraxylon fragments appear in other parts of the photograph. Plate LXII, *B*, is from an area of the section included in the former photograph, magnified 1,000 times. Besides the spore-exines common in the Pittsburgh seam, such as are shown in Plate LXI, *B*, it shows other species of spores common in almost all coals examined. (See chapter on "Spore Exines," p. 67.)

EXPERIMENTAL MINE COAL; HORIZONTAL SECTIONS.

Horizontal sections of any coal are always of special interest, as they bring out much general detail that is usually overlooked, particularly the individuality of the various components. Although this is true of all the coals shown, it is especially true of those from the experimental mine. Study of these photographs, and those of cross sections, will remove any wrong ideas as to the homogeneity or amorphous condition of the mass.

Plate LXXV, *A*, represents a section through a typical attritus consisting of very finely divided humic matter, spore-exines, a little resinous matter and the more highly carbonized matter, and some earthy matter, each clearly distinguished from the other. Plate LXXIII, *A* and *B*, and Plate LXXIV, *A*, both magnified 150 times, show the same wherever the sections cut through the attritus. These should be compared with Plate LXXV, *A* and *B*, and Plate LXXVI, *A* and *B*, at a magnification of approximately 1,000 diameters. In some of these certain objects such as spore-exines appear to be embedded in a homogeneous mass, as

in Plate LXXV, *B*. On close inspection it will be seen that the section includes an anthraxylon fragment, in which the woody structure is clearly recognizable, and that the individual particles composing the attritus lie closely against the former but are not actually embedded in it. If such a section is compared with a cross section, especially at a magnification of 1,000 diameters, it will be seen how closely packed and how intimately united the particles are, nevertheless representing definite and individual objects with definite boundary lines. Plate LXXV, *A* and *B*, gives a clearer idea of the sculpturing of the predominating spore-exine in this coal than any of the other photographs. Plate LXXVII, *A* and *B*, represents cross sections of the coal of the Pittsburgh seam from Madison, Pa., and Plates LXXVIII to LXXX from unknown localities of the Pittsburgh seam. These coals do not differ materially from those already discussed.

SECTIONS OF OTHER COALS.

ILLINOIS COALS, FROM THE NO. 6 BED.

In general the coals from the No. 6 bed of Illinois, namely, from the Hart-Williams mine, from the mine of the Benton Coal Co., both near Benton, from Zeigler, Royalton and Sesser, all in Franklin County, are similar to the Pittsburgh coal. As detailed an interpretation as was given for the Pittsburgh coals will not be necessary as the reader has become familiar with the appearance of the coals in the photographs, and is able to interpret them himself. Plates LXXXIX to CX represent coals from vein No. 6 of the Illinois coals. When Plates LXXXIX to XCI, Plate CVI, and Plate CVIII of the Illinois coals are compared with Plates LI, *A*; LIII, *A*; LIV, *A*; LXIX, *B*; LXXVII, *A*; and LXXX, *A*, of the Pittsburgh coal, the resemblance of the attritus is striking. Many photographs could be taken that would practically duplicate each other. Plate LXXXIX, *A*, and CVIII, *A*, show typical attritus of these coals. Interlayered between the anthraxylon strips, the spore-exines may be recognized embedded in a matrix consisting of humic matter, resinous particles, and the opaque or more highly carbonaceous matter. In the sections under the microscope various mineral constituents may be observed, as in the Pittsburgh coals.

Plate LXXXIX, *B*; Plate XC, *A* and *B*; Plate XCV, *A* and *B*; Plate XCVI, *A* and *B*; and Plate CVIII, *B*, at a magnification of 1,000 diameters, show that the attritus is here also composed largely of definite particles intimately united into a compact mass.

The ratio of the various constituents forming the mass varies considerably, but on the whole the proportion of carbonaceous matter is small and the proportion of humic matter is large. The propor-

tion of spore-exines is variable not only in the different coals from the vein, but also in different sections of the coal from the same locality, and even in the different striæ in the same section. Spores form an appreciable part in these coals, as large a part as in the Pittsburgh coal.

THE COAL FROM THE BUXTON MINE.

The attritus of the Buxton coal is composed of the same kinds of constitutents as that of the other coals, but the constituents are comparatively coarse. The spore-exines are large, the humic matter consists chiefly of coarse irregular, flat particles, and the resinous matter consists of large, regularly shaped particles. These constituents are mixed with a large proportion of opaque matter, which in certain layers appears as definite irregular particles; in some it is arranged more or less in sheets and in others it forms the embedding mass for the other constituents. This is well illustrated in Plates CXXV to CXXVII. Much of the opaque component is earthy, and differs from the carbonaceous matter, of which there is also a considerable amount present, in that it is absolutely opaque and has an earthy appearance. Although the relative proportion of the organic constituents of the attritus varies from place to place, in most of the samples there is about 50 per cent of each. Granules of iron pyrites form a considerable amount of the attritus of this coal.

THE SIPSEY COAL.

The attritus of the Sipsey coal, shown in Plates CXXXVII–CXXXIX, varies considerably in its appearance and in the relative amounts of its constituents, although the latter are of the same kind as in other coals. It is similar to that of the Pittsburgh coals; in some respects and similar to that of the Buxton coals in others, and may be said to consist of two kinds. It contains less opaque earthy matter and is, therefore, of a lighter color than the attritus of the Buxton coal. The resin content is also lower and the humic matter is more finely divided.

THE VANDALIA COAL.

As has already been pointed out, the Vandalia coal is very anthraxlous and contains only a small amount of attritus. This is similar in content to the attritus of the Illinois coals, though it contains much finely divided humic matter and relatively little spore matter. Iron pyrites grains are fairly numerous in the attritus, and are sufficiently abundant in some layers to give them an opaque appearance. (Pls. CXLIII to CL.)

THE CARBON HILL COAL.

The attritus of the coal from Carbon Hill is in every respect very similar to that of the Pittsburgh coal. (Pls. LXXXIV–LXXXVIII.)

THE COMPONENTS IN DETAIL.

In the foregoing chapter the author has sought to show that in all ordinary bituminous coals the attritus is similarly composed and that it is analogous to the attritus in peat. Although the proportions of various constituents may vary considerably, or their appearance and kind may differ slightly, in general they are all of the same class. The main constituents forming the attritus will be considered under five heads, as follows: The humic matter, resinous matter, the spore-exines, fungi, other organisms, the carbonaceous matter, and the rodlet.

THE HUMIC MATTER.

Humic matter comprises all matter in a finely macerated condition derived from plant tissues, but usually not revealing original cell structure, and does not include spore-exines, pollen-exines, cuticles, and resinous matter. The latter class of components is of microscopic fineness, including particles easily visible under the microscope, and such as are too fine to be recognizable except by ultramicroscopic means. The latter class is usually termed "homogeneous matter," and there is remarkably little of it present in most coals. The origin of the humic matter is considerably wider than that of the anthraxylon, as was seen in the study of the origin of the attritus in peat. Chemical tests and the history of humic matter in peat show it to be chiefly of cellulosic and lignocellulosic origin. It consists largely of macerated wood fibers and parenchymatous cells, with some macerated walls of bark, cork, phloem, pith, leaf tissues, and also some gummy substances from any and every plant that contributed to the deposit. It has therefore much the same nature as the anthraxylon.

The color as seen in thin sections is similar to that of the anthraxylon, ranging from a light orange to a deep red. Its physical appearance is also similar to that of the anthraxylon of the same coals, and by its color and physical nature it may readily be distinguished from the other constituents of the attritus.

The humic matter has already been indicated in the photographs accompanying the general discussion of the attritus. Although humic matter is apparent in every photograph showing attritus, reference is made to the following photographs in order to recall its general appearance and nature. Plate LIV, *A*; Plate LV, *B*; Plate LVIII, *A*; Plate LXI, *A* and *B*; LXII, *A* and *B*, of coal from the Oak mine;

Plate XLIII; Plate LXX, *A* and *B*; Plate LXXII, *A*; Plate LXXIV, *A* and *B*; Plate LXXV, *A* and *B*; Plate LXXVI, *A* and *B*, of coal from the experimental mine; and Plate LXXIX, *A* and *B*, and Plate LXXX, *A* and *B*, from other parts of the Pittsburgh seam, give a good idea of the humic matter contained in the Pittsburgh coal.

Other good illustrations are Plates LXXXVI and LXXXVIII, *A*, of the Carbon Hill coal. Plate LXXXIX, *A*, and particularly Plates LXXXIX, *B*; XC, *A* and *B*, at 1,000 diameters, of the Hart-Williams coal; Plate CVI, *B*, and Plate CVIII, *A*, of the Royalton coal, give good illustrations of the humic matter in the Illinois coals in a granular condition, and Plates XCV and XCVI show it in a homogeneous condition. Attention is called to Plate CIII, *A* and *B*, and Plate CIV, *A*, of the Sesser coal, which show much humic matter in the shape of large irregular, angular bodies, differing in appearance from either typical humic or resinous matters. The most pronounced granular or comminuted condition is found in the Shelbyville coal, shown in Plate CXV, *A*, and Plate CXVI, *A*. Plate CXV, *B*, and Plate CXVI, *B*, at 1,000 diameters, from the same coal, do not show the granular condition so well, but do show the nature of the very fine humic matter in which the larger humic particles and the spore-exines are embedded. The Buxton coal has a mass of coarse material of various forms and appearance (Pl. CXXIV, *B*), consisting largely of irregular flat particles, in places associated with rounded particles (Pl. CXXV, *B*) that may be resinous or merely humic. Bodies of a similar nature appear in Plate CXXVI, *B*. As they are lighter colored than the anthraxylon and other typical humic matter, they may be resinous. The appearance of the humic matter in horizontal sections of this coal is shown in the Plates CXXVIII, *A* and *B*, and CXXIX, *A* and *B*.

An examination of the photographs at 1,000 diameters will show that there is very little humic matter in a homogeneous condition, to which fact due attention has been called in connection with the general discussion of the attritus.

THE RESINOUS MATTER.

Universally scattered through the attritus of all bituminous coals are certain particles that form an appreciable part of many coals. These are rarely angular, have a homogeneous consistency, are brownish red and similar to the anthraxylon components and the humic matter in color, and are optically active.

They are termed resinous bodies or particles, as they are analogous to the resinous components of the lignites, the origin and identity of which are more certain. Microchemical tests give positive testimony of the resinous nature of these bodies in the lower grades of

lignites, but every attempt to obtain proof of their resinous nature in bituminous coals has failed. For that matter, in coal derived from the woody or cellulosic parts of plants chemical tests also fail to show their chemical nature or origin, but here the remaining original plant-cell structure in which they are found furnishes positive proof of origin. The free resinous matter shows also the form and other characteristics like that of the resinous matter in recent plants, but this evidence is not as reliable or as certain as the presence of the remaining cell structure of the anthraxylon components.

OCCURRENCE.

The so-called resinous components still remain, as a whole, the least known and the most indefinite constituents of bituminous coal and the most uncertain as to origin.

Fortunately there are a number of transition stages from that in which the resinous particles are included in a fairly well preserved woody tissue to that where they are free in the attritus. Plate CL, *A*, shows an anthraxylon component in parts of which the tissue including numerous resinous particles in its characteristic way is very well preserved, and leaves no doubt that it is a remnant of a resinous plant; in other places of the same piece the woody tissue is in various stages of decay, the cells appear disintegrated and indefinite, and the resinous particles, apparently well preserved, lie free in the débris or are partly included in fragments of the tissue. This is partially shown in Plate CXLIX, *A*. In other places the cell structure has disappeared almost completely, leaving little else but the resinous matter. (Pl. CXLIX, *B*.) Furthermore, the Vandalia coal contains a number of other anthraxylon strips in which similar resinous bodies are still included in situ. (Pl. CL, *A*.) Numerous resinous bodies similar to these are scattered free throughout the coal. The Vandalia coal may be termed an anthraxylon coal, and many of the anthraxylon components are resinous. Some of the resins included are of the kind mentioned, others differ, but many of the types seen in place are also recognized among those scattered free through the coal. Similar transition stages have been observed in other coals.

Here, then, are certain constituents that are included in the tissues of certain plants. In the living plants such inclusions are almost always the natural resins, though a few may be gums and waxes. There is every reason to believe that similar inclusions in the tissues of the Paleozoic plants are resins, and that a few may be gums or waxes. Bodies or particles that resemble in every respect the inclusions in the anthraxylon components are found free in this

coal; and the conclusion that these also are of a similar origin and are resins or resinous particles is reasonable.

Every coal examined has particles of similar nature and appearance scattered through it. Some coals, like the Vandalia coal, contain a great many, probably one-fourth to one-third of certain laminæ of this coal being of a resinous nature; other coals contain much less. The Buxton coal contains the next largest percentage of resinous matter. (Pls. CXXIV–CXXVII.)

SOURCES.

Three sources of resinous secretions are recognized in living plants: The stem, the bark or cortex, and the leaves. Only evidences of resinous contents of the stems have previously been cited. In the Buxton coal appearances clearly tend to show that some of the resin particles scattered through the débris undoubtedly had their origin in the stems of plants, as similar types are found still in place in great numbers; but others apparently had their origin in leaves. The latter lie in straight rows, in single, double, and occasionally in triple rows. Frequently they are included between rather heavy cuticles, as shown in Plate XCVIII, *A* and *B*, of an Illinois coal. When thus associated with cuticles, it seems that they are the residue of the leaf of which the cuticles once were a part. When they are not included between cuticles the evidence is not so clear. Plate CXXVI, *B*, shows a single row of resinous-appearing bodies not included between cuticles. Resinous particles included between cuticles are found also in other coals.

Besides these two classes that may be associated with each other, there are in these coals a large variety of particles scattered throughout the débris that can not be definitely placed, but nevertheless, have all the characteristics of resins. Plate CIII, *B*, and Plate CIV, *A*, of the Sesser coal, show particles that are of a resinous consistence, but do not have the usual form of resinous particles.

DISTINGUISHING CHARACTERISTICS.

Although the resin particles resemble the anthraxylon or humic components closely in color, transparency and consistence, they may usually be distinguished through their form and particularly through their homogeneous consistence. When examined in cross sections the resin bodies appear rounded or oval, rarely angular, whereas the humic components even when in minute fragments are thin and flat and usually angular. The resinous substance is homogeneous, or finely granular, whereas the substance of the humic matter is always coarsely granular and readily distinguishable from the former.

In the horizontal sections the distinction between the resinous and humic contents through their form is not always so easy, especially when the former had their origin in wood fibers and the latter are in a fragmentary condition. But when the resinous particles are ovoid or approximately spherical, as shown in Plate CXLIX, *B*, they are easily distinguished. Often when the resinous particles are from the contents of a cell fiber, as in the wood of our recent conifers, the particles contain peculiar constrictions, or indentations, or a number of vacuoles that identify them. Most resin particles, whether ovoid, spherical, or fibrous, contain numerous vacuoles or fine bubbles that appear to be characteristic of resinous bodies. Nevertheless, there remains a relatively small amount of the fragmentary matter that must be classed either with the resinous or the humic matter, but can not as yet be safely identified.

Characteristic resinous particles are shown in Plates CXLVII, *B*, CXLVIII, *B*, CXLIX, *B*, of the Vandalia coal; Plates XLIX, *A* and *B*, L, *A*, LXX, *B*, LXXVIII, *A*, of the Pittsburgh coal; Plates XCIII, *A*, XCIV, *B*, C, *B*, of the Illinois coal; and Plates CXXV, *A*, and CXXVI, *B*, of the Buxton coal.

THE SPORE-EXINES.

Next in importance in the attritus are the spore-exines. None of the coals examined are free from them. Even the coal with the least number of spore-exines, the Vandalia coal, contains on the whole a considerable proportion of exine matter. Examination of the photographs will probably not give an absolutely correct idea of the proportion of spores to other components of coal, but they may be depended upon to furnish a general idea of the proportion of spores in the attritus. The photographs taken at a magnification of 200 diameters have for the most part been selected to show average conditions.

No attempt at taxonomic identification was made, as that would involve an extensive study and would probably be out of place here, no matter of how great interest it may be in other fields. Only such characteristics will be pointed out, as size, form, structure, distribution, types and predominance of certain types in certain coals.

SOURCES.

As to the origin of those bodies, called spore-exines, there can now be no doubt. The only question that can arise is whether they are the exines of true spores of mosses, Lycopodiales, and Filicales, or the pollens of gymnosperms.

Thus there is the possibility of having in the Paleozoic coals spores from three great groups of plants: Mosses, Pteridophytes,

and Gymnosperms. The Pteridophytes may be conveniently divided into three great families; the Calamites, in which may be classed the horse tails; the Lycopodiales, to which belong the club mosses or ground pines; and the Filicales, to which belong the ordinary ferns; the gymnosperms comprised two families, the Cycadofilicales, and the Coniferales. The spores of the last two groups are true pollens. As has been stated repeatedly, all that has survived through the coal forming processes is the outer spore wall or exine, and the chemical nature of the exines,[a] whether of spores or pollens, is similarly composed. In the living plants this has been shown in the spores of Lycopodium clavatum by Langer, and the pollen of the hazel by Von Planta, and of Pinus sylvestris by Von Planta and by Krestling.[a]

There is every reason to believe that the chemical composition of the Paleozoic plants was not materially different from that of any of the recent plants. Their life functions and their chemical and physical processes of life and growth must have been the same as that of the plants of to-day. The spore-exines in coal owe their preservation to their resistant chemical nature, a characteristic also of the spores of recent plants.

Under the microscope the spore-exines, on account of their transparency and clear color, are the most conspicuous objects in the coal. They contrast sharply with the woody components and the resinous particles, or with any of the constituents of coal except the cuticles, which are similar in color and transparency, and are, therefore, readily distinguishable. In thin sections by transmitted light they are clear light yellow; in thicker sections they are golden yellow to light orange. Their consistence is finely granular, particularly noticeable at high magnifications. These features are the same for the exines from all the coals examined. At magnifications of about 1,000 diameters spores usually show specific differences through various characters that are well preserved. They have usually retained the common flattened shape so apparent in the photographs from the cross sections. This is nearly always due to the collapse of the shell or exine of the spore through pressure. Change of form otherwise than by flattening is not characteristic of any coal in particular. For example, in the coal from the Vandalia mine the exines in some striæ have assumed a lenticular form, whereas in the same section in another lamina they are present in the natural shape. Sometimes they look as though melted into a little lump. But this condition is sometimes found in certain striæ and sometimes among well preserved exines.

In horizontal sections the spore exines appear as circular or oval areas, many of which tend to be triangular. When isolated from the

[a] White, David, and Thiessen, Reinhardt, Origin of coal: Bull. 38, Bureau of Mines, 1914, pp. 274, 275.

coal they are thin disks, unless they have been changed in some way or another into irregular shapes.

TETRASPORIC MARKINGS AND SCULPTURING.

All the true spore-exines show the tetrasporic markings, which are usually on the broad side; the exine predominant in Pittsburgh coal has these markings most often along the periphery of the disk. The outer surface of an exine may be smooth, sculptured or beset with spines, papillae, or other appendages; in many exines these are arranged in definite order and occur in a variety of forms. These sculpturings may be serpentine ridges, as in the predominant exine of the Pittsburgh coal (Pls. LXI, *B;* LXXV, *A;* and LXXXII, 1 and 2), or merely irregular elevations, as in the exine from the Sesser coal (Pl. CXII, 7); they may be echinate spines, as represented in Plate CXXXVI, 3, long heavy spines, as shown in Plate CXI, *A* and *B*, or delicate spines, as in Plate CXII, 2 and 3; they may consist of ramenta covering either the whole surface, as shown in Plate, CXXXII, 1 to 4, or confined to a small area, as in the exines shown in Plate CXXXV, 1 to 6. The outer part of some exines has developed into a thin fringe or border surrounding the whole spore (Pls. CXVII, 1), appearing as a zone in the collapsed exine, and in some exines the outer part has developed into sacks, of which there are three in the Buxton megaspore-exine shown in Plate CXXX, *A* and *B*, and Plate CXXXI, 1 to 4; and others have a number of wings, as shown in Plate LXXII.

In the exines of the pollen the disks are invariably oval or ovoid. They have no tetrasporic marks, but almost all have a slit parallel to the long axis of the oval. Many of these slits have a short cross slit at or toward one of the ends. So far as can be observed the surfaces of the pollen exines are smooth. They are all similar in shape but differ greatly in size. (Pls. LXII, *B*; LXXVI, *A* and *B*; LXXXII, 4; CXII, 4 and 6; CXVII, 3; CXXIX, *A* and *B*; and CXXXVI, 2.) This type of exine has been found in every coal examined, and in some coals it is the predominant type of spore matter.

MICROSPORES AND MEGASPORES.

As with the spores of the living plants there are in the coals two kinds of spores—megaspores and microspores. Microspores develop in large numbers in a sporangium and are relatively small. Only one, or a few megaspores develop in a sporangium and they are relatively large. The size of the spore does not distinguish a microspore from a megaspore as much as does its mode of development and especially its function as a spore in the living plant.

DISTRIBUTION.

The proportion of the spore-exines present in the coals examined varies greatly. The Vandalia coal, as observed from standard samples and one large lump on hand, contains the least of all coals examined, but the coal from Sesser, Ill., does not contain any more. The coal from Shelbyville, Ill., contains by far the most, approximately one-fourth to one-third of the coal being composed of exines. Attention is called to the fact that the cannel coals as far as examined, are composed largely of spore-exines, but cannel coals are not considered in this paper. All the coals examined from the Pittsburgh bed contain a large proportion. Equal to these in spore-exine contents are the coals from the Sipsey mine, Rock Creek bed, in Alabama, and the coal from Buxton, Iowa. The coals examined from Benton, Ill., and Zeigler, Ill., probably contain the average proportion.

The distribution of the spore-exines can best be ascertained by examining the plates. The spore-exines may be very numerous in some layers of attritus and almost absent in another layer in the same section. In some layers they may represent the largest part of the layer, and in others only a small part. In many spots they are bunched and constitute almost the whole lamina or sheet. (Pl. CXIX, *B*.) These densely crowded laminæ may lie between pieces of anthraxylon or in the attritus.

SPORANGIA AND CONES.

All the coals examined included nests or lenticular mats that can be isolated quite readily through the maceration process; these prove to be more or less circular lense-shaped bodies about the size of small megaspores and are composed of innumerable microspore-exines very closely united. These are particularly abundant in the coals from Shelbyville, Ill., and Buxton, Iowa, but are found in all coals. (Pl. CXXI, *A* and *B*, and Pl. CXXII, *A*.) Many are still surrounded by a wall in which the tissue is still well preserved. (Pl. CXXXIII, *A* and *B*, and Pl. CXXXIV, *A*.) Occasionally large nests of such lenticular aggregates of spore-exines, some inclosed by a sporangial wall, are found in close proximity. (Pl. CXXXII, *A* and *B*.) Occasionally a large number are found packed together, some being inclosed in a well-preserved wall, all arranged around a common axis, and many showing definite remnants of trabeculæ. (Pl. XIV.) These are the remains of sporangia, clusters of sporangia and cones.

The light region at co in the photograph of the lumps of coal from the Benton coal shown in Plates XII and XIII represents part of such a cone. Plate XIV shows part of the same cone magnified ten times. At a higher magnification the remaining cell structure of

the axis and sporophylls are clearly recognizable, as also the trabeculæ of the sporangia.

One of the sporangia in the Buxton coal shown in Plate CXXI, *A* and *B*, at a magnification of 10 diameters, is shown in part in Plate CXXXIII, *A* and *B*, at a magnification of 200 diameters.

In Plate CXXXIII, *A*, the tip of the sporangium is shown, also the sporangial wall, which is covered with a cuticle and in which the cell structure is clearly recognized. In Plate CXXXIII, *B*, a more central part of the sporangium is shown. At 1–sp are seen the immature spores, at 2–w the inclosing wall, and at 3–d the attritus composed of anthraxylon matter, resinous matter, spore-exines and more carbonaceous and earthy matter. Plate CXXXIV, *A*, represents part of the former at a magnification of approximately 900 diameters, showing particularly the cell structure of the spore wall and the cuticle overlying it. Plate CXXXIV, *B*, shows the spores of the same sporangium, also at a magnification of approximately 900 diameters; Plate CXXVII, *B*, shows the attritus including spore-exines, shown in Plate CXXXIII, *B*, at a magnification of 1,000 diameters.

An examination of these shows that the spore-exines of the débris and those still contained in the sporangium wall are of the same kind—conclusive evidence that the predominant spores of the coal are from plants that grew in the bog during the peat-forming stage, as it would be impossible for whole cones and sporangia with immature spores to have been carried far by winds.

All the coals examined contain, besides the free spore-exines distributed through them, these nests or aggregates of spores representing sporangia or part of cones or whole cones. These are evidently the bodies called middletonite[a] by Johnston.[b]

TYPES.

No thorough classification of the spore-exines found in the coals has been made. This problem is chiefly of palaeobotanical interest and out of place here, except for its stratigraphic value. This would permit the classification of certain types of spore-exines in their proper phyla, order, family, genera, or species. For the present reference is made to each exine that is predominant in or characteristic of a certain coal deposit. To try to give a definite name to them without knowing their affinities and relationships, as has been done by some in the past, would be a waste of time and space. No benefit is gained by naming the exine predominant in and charac-

[a] White, David, and Thiessen, Rheinhardt, Origin of coal: Bull 38, Bureau of Mines, 1914, p. 193.

[b] Johnston, James F. W., On the composition of certain mineral substances of organic origin. The London and Edinburgh Phil. Mag. and Jour. of Sci., vol. 12, 1838, pp. 162–163.

teristic of the Pittsburgh seam "Sporangites" Pittsburghensis as does Dawson, or "Trilet" Pittsburghensis, as does Bennie and Kidston, or giving some such meaningless name. When their relationships are known proper names will be given them.

GROUPING OF COALS BY THEIR SPORE-EXINES.

Coals from certain beds contain a type of spore-exines that is predominant in or characteristic of that bed, or both. Even a casual examination of the photographs of the coals from the different localities from the Pittsburgh bed, for example, will reveal a striking similarity in the predominating mass of the spore-exines. A closer examination shows that the exines are of the same type in every part of the seam. In comparing the coal from the Sipsey mine, in the Black Creek bed, with that from Carbon Hill, in the Jagger bed of Alabama, the type of the exine in each is strikingly different, but the predominating mass of exines in each coal are all of the same kind. The same is true for the Buxton coal and for the microspores of the Shelbyville coal. In each of these coals the predominating spore is characteristic of that coal, for it is found only in that coal. Other spore-exines are characteristic of a certain bed, but are not the predominant spore, as the beaked megaspore in the Buxton coal or a heavily spined exine in the coal from the Hart-Williams, Buxton, and Zeigler mines.

Although not enough coals from the Illinois and Indiana coals have been examined, the observations so far indicate that these coals may be grouped with respect to the predominating or the characteristic type of spores they contain. This subject may find a wide application in determining the different beds in the Illinois coal fields, and it deserves careful development.

SPORE-EXINES FROM THE PITTSBURGH SEAM.

In the photographs of the coals of the Pittsburgh bed from the experimental mine, the Oak mine, Madison, Connellsville, a mine in Ohio, near Moundsville, W. Va., and lumps picked up from time to time from coal delivered in Pittsburgh for household use, one type of spore-exines predominates in the coal from each locality; closer examination shows a second type, of a larger size, but in relatively small numbers. These two types so far have only been found in the Pittsburgh bed and hence are characteristic of it. Besides these two kinds a number of others occur in relatively smaller numbers, but they are also found in other coals.

The characteristic spore-exine of the Pittsburgh seam is a flattened ovate disk with an average diameter of 15 by 16 microns. It is therefore, the exine of a very small spore. The surface is molded

into closely folded, blunt, serpentine ridges. (Pl. LXI, *B;* Pl. LXXV, *A*, and Pl. LXXXII, 1 and 2.) These ridges seem to be arranged symmetrically with respect to the tetrasporic markings. In some of the exines, as seen in horizontal sections, a groove, which is a part of the tetrasporic marking, runs across the disk, to which the serpentine ridges on either side are symmetrical. (Pl. LXI, *A* and *B*.) This groove is rarely exposed in horizontal sections. The spore may be readily isolated from the coal by means of the maceration process and studied from all sides. The groove is then seen to lie along the periphery of the disk and to be part of the tetrasporic marking of the spore. In all probability, the groove formed the weakest line or the most flexible zone in the thick exine, and when the exine was put under a stress and the walls collapsed, the bending occurred along this line and hence lay along the periphery in most of the spores. The spore rarely bent at another line than the tetrasporic groove, in which event the groove lay across the disk. In some of the exines the ridges are arranged symmetrically around a certain point or pole of the disk, Plate LXXXII, 2. The disks of such exines are more nearly circular, but some tend slightly to be triangular. The serpentine ridges on the surface give the exine an irregular wavy outline when seen in cross sections at very high magnification.

The large spore-exine characteristic of the Pittsburgh bed is shown in Plate LXXVII, Plate LXXX, *B*, and Plate LXXXI, *A*, at a magnification of 1,000 diameters. Cross sections only have been obtained of this type. It is similar in nature and appearance to the smaller spore just described, but is much larger, measuring between 70 and 90 microns across the disk.

SPORE-EXINES FROM THE SIPSEY MINE.

The coal from the Sipsey mine has also one predominant and characteristic type of spore-exine. Whether this type prevails throughout the coal bed worked by the Sipsey mine remains to be seen, as only one can of samples taken according to standard methods has been examined from that bed.

The collapsed exine as it occurs in the coal is roughly salver shaped. The disk is not quite circular, but slightly triangular. Its cross section (Pl. CXXXVIII, *A* and *B*, and Pl. CXXXIX, *A* and *B*) is roughly that of a plano-concave lens, because of the difference in the thickness of the spore wall. In that area of the spore walls where the four spores were united during the tetraspore formation the exine is relatively very thin, whereas the other part of the spore wall is relatively thick. When the spore contents disappeared through decay and the remaining spore wall finally collapsed, this thinner area was almost always pressed down against the relatively thick part opposite, but a part of the thicker area lying on the pe-

riphery of the thin area was drawn over with it, thus forming a thick outer rim. The isolated spore-exine is shown in Plate CXLI, *B*.

The diameter of the disk of the collapsed spore is between 40 and 50 microns (1/20 mm.), so that the spore was large as compared with the predominant spore of the Pittsburgh bed. The surface is studded with numerous small spines that have a tendency to arrangement in spiral rows.

Many of the exines in the samples examined are well preserved, others are so changed that they present only an irregular mass or little lumps of exine matter, and between these two extremes are all stages. The state of preservation varies in different sections and in different striæ of a section.

SPORE-EXINES FROM THE BUXTON COAL.

A number of interesting types of spore-exines appear in the coal from the Buxton mine. One type is the predominant, and, so far as now ascertained, the characteristic type; another, a small megaspore, seems to be characteristic of this coal, but is by no means predominant.

The spore-exine predominant in the Buxton coal is similar in shape to that of the Sipsey coal. It roughly resembles a plano-concave lens, but the disk is usually oval instead of slightly triangular. (Pl. CXXXVI, 1.) The tetrasporic area of the exine—that is, that area in which the four spores were united during the growth period—appear to be thinner and the free area thicker than the corresponding parts of the Sipsey exine. The thicker part of the spore wall, furthermore, contains numerous vacuoles of varying sizes. For this reason, the texture of the cross section strongly resembles the cross section of an almond shell. Plate CXXVII, *B*, shows the exine in cross section, and Plate CXXXVI, 1, on the broad side. These vacuoles give the exines a reticulated appearance when seen on one of the flattened sides. Spore-exines of similar appearance are found in the cannel coal from Caldwell, Mo.[a]

In the Buxton coal also the remains of parts of or of whole sporangia occur to a large extent, either separate or grouped together into cones or parts of cones. Frequently the sporangium walls still include the spores and in so good a state of preservation that the cell structure is still clearly shown. (Pl. CXXXIII, *A* and *B*, and Pl. CXXXIV, *A*.) Sometimes the spores included appear to be immature. The spores of almost all the sporangia are of the same type as those that form the predominant type of the coal.

MEGASPORES.

The most interesting spore-exines of the Buxton coal are its megaspore-exines, of which there are several types. The more prominent

[a] White, David, and Thiessen, Reinhardt, The origin of coal: Bull. 38, Bureau of Mines, 1914, p. 250.

type, shown in Plate CXXX, *A* and *B*, may easily be isolated by means of Schulze's maceration reagent, and then handled with forceps for examination. It is relatively large, though not the largest found in the coal, measuring approximately one millimeter across the disk, exclusive of the wings. In a collapsed condition its shape is somewhat triangular, as seen in the photographs just mentioned. This exine is remarkable because of its wings; normally there are three, formed by an extension of the exine wall into long thin-walled sacks. These sacks are extremely delicate and break off in an attempt to remove the exine from the mass. In Plate CXXX, *A* and *B*, they appear as short tongues, and represent but a part of the original appendages. A cross section of the exine while still lodged in the coal gives a better idea of the sack and its delicate nature, as shown in Plate CXXXI, 2, in which one of the three sacks, somewhat folded, is seen in cross section. The inner cavity of the exine communicates with the interior of the wing. Plate CXXXI, 1, 3, and 4, are also cross sections of the same kind of spore but the wings are not so well shown. Megaspores similar in size, shape, and general appearance are found in the Shelbyville coal, but the wings here are but very short or stunted compared with those of the Buxton exine. (Pl. CXVIII, *B*, and Pl. CXIX, *A* and *B*.)

Another interesting megaspore-exine (Pl. CXXXV, 1 to 6), has on a small area a profusion of long ramenta, now much curled and disheveled. In the living plant presumably the ramenta start from this area much as the pappus of a thistle or a dandelion seed. The exine is of about the same size as the one described previously but much thinner. It has been found also in the Ziegler and the Royalton coals, though not so frequently.

In another type (Pl. CXXXII, 1 and 4), the whole surface is covered with a ramenta. Plate CXXXII, 1, represents one of these in cross section at a magnification of 40 diameters. Plate CXXXII, 2, at 200 diameters, shows the left end, and Plate CXXXII, 3, also magnified 200 times, shows the right end of the same spore in better detail. Plate CXXXII, 4, shows the end of another exine of the same type. So far this type has been found only in the Buxton coal. Besides these, other megaspores of the ordinary type similar to those of other coals are found, including the giant megaspore prevalent in the Shelbyville coal. (Pl. CXVIII, *A*.)

PREDOMINANT EXINES OF THE SHELBYVILLE COAL.

Another coal in which by far the greater proportion of the exines are of one type is that from Shelbyville. The exine was described[a] as constituting the bulk of the spore matter of that coal. This type

[a] White, David, and Thiessen, Reinhardt, The origin of coal: Bull. 38, Bureau of Mines, 1914, p. 263.

of exine averages approximately 100 microns in diameter, measured across the disk. It has a darker central area which constitutes the spore-exine proper, measuring approximately 40 to 50 microns across the disk, and is comparatively thick-walled. This part is surrounded by a much thinner border approximately 25 to 30 microns wide, the unequal width gives a triangular outline. (Pl. CXIII, *B*.) Evidently this border served as a wing in the living spore. The tetrasporic marks extend across the inner or main portion of the exine.

A smaller microspore, found in large numbers, is conspicuous and dominant. It is only a little larger than the central or main part of the spore-exine just described. Its tetrasporic marks are prominent. (Pl. CXVII, 2.)

A giant megaspore of the Shelbyville coal measuring approximately 3 millimeters in diameter is the predominant type of megaspore. It can easily be seen in the coal with the naked eye, appearing as little brown disks. Plate CXVIII, *A*, represents an isolated spore, magnified 35 times. This spore-exine has been found in smaller numbers also in the Buxton and the Pittsburgh coals. A smaller megaspore found in considerable numbers in the Shelbyville coal is shown isolated in Plate CXVIII, *B*, and Plate CXIX, *A*, and in cross section still lodged in the coal in Plate CXIX, *B*. The spore-exines resemble very closely the smaller megaspore-exine found in the Buxton coal in size, general form, and thickness of spore wall, except that the wings or the sacks of the Shelbyville exines are comparatively short and rudimentary. This is clearly shown in Plate CXIX, *B*, a section through a pad of these exines.

SPORE-EXINES IN THE ILLINOIS COALS OF BED NO. 6.

The Illinois coal from bed No. 6, as far as has been examined, contains a number of the different types of spores found also in most coals, but there seems to be no predominant type. One type of spore, however, seems to be characteristic in the vein, and to predominate in the Sesser coal. It is an exine of medium size, between 30 and 40 microns in diameter, slighly triangular in shape, irregularly sculptured, and with thick walls. The isolated spore is shown in Plate CXII, 7, and a cross section of the same type still embedded in the coal in Plates XC, *A;* XCVI, *B;* XCVII, *B;* CIV, *B;* and CV, *A* and *B*. Other types characteristic to this bed may possibly be discovered later. Spore-exines with long blunt spines (Pl. CXI, *A* and *B*) and a type of large nutlike exine (Pl. CXII, 4 and 6) have been found only in these coals.

THE CARBONACEOUS MATTER.

The carbonaceous, or more highly carbonized matter, or the darker and more opaque matter, present in all coals, occurs in many forms.

Two kinds are usually recognized. One has definite structure and clearly represents highly carbonized parts of cells or small groups of cells and bits of tissues, and is, therefore, anthraxylon and humic; the other is irregular and disorganized and of uncertain, though plainly organic, origin; no cell structure is evident. In sections of ordinary thickness the particles of both kinds range from opaque to barely translucent and are dark red. In very thin sections most of the particles are translucent and dark red. The irregular particles are generally the less translucent and also the more abundant.

When a coal is dissolved by means of the Schulze method, that is, if the reaction is not carried too far, these constituents remain behind, together with the spore-exines and cuticles, and in this condition their nature is best studied.

THE MORE HIGHLY CARBONIZED ANTHRAXYLON.

The identity of the carbonaceous anthraxylon particles is not readily established in the cross section, except when they appear as larger groups of cells or bits of tissues, but, on the other hand, it is easily determined in horizontal sections in which the carbonaceous particles are common. In some sections there may be only a few, but in others many are present, as shown both in the sections and in the residue after a dissolution of the coal in Schulze's reagent. They may have had their origin in any plant that contributed to the coal and may either be of chollenchymatous or parenchymatous origin, usually the former. As already intimated, they may consist of only a fragment of a cell or fiber or tissue, or of groups of fragments (Pl. LX, *A*). When fragments of cells, they range in size from the most minute particles to whole cells or fibers. When in groups they range from a few cells to a large part of a tissue (Pl. LX, *B*), and in the latter state form charcoal or "mother coal." All the photographs, both of vertical and horizontal sections, show this component in one way or the other.

The cell structures in the carbonized anthraxylon are nearly always well preserved, often as well as in petrified wood or in living plants, and all the cell characters known, such as spiral and sclerenchymatous thickenings, bordered pits, etc., are easily recognized. When in the shape of cells or group of cells the walls usually have retained much of their natural shape.

The finer carbonaceous matter of this class also is nothing more than finer particles or smaller fragments of the common charcoal or "mother coal."

THE DISORGANIZED CLASS OF CARBONIZED MATTER.

The more irregular opaque bodies are not so easily defined. These are apparently of divers origins and occur in a variety of forms and

shapes. Some are irregular, others almost spherical, with all possible gradations between. In size they range from microscopic particles to those visible to the eye; the former being more numerous. A large portion of them are clearly more highly carbonized resinous matter; the origin of others is uncertain. The more spherical particles suggest resinous matter. (Pls. L, *A*; LII, *B*; LIII, *A*; LIV, *B*; LXV, *B*; LXIX, *B*; LXXIX, *A*; and LXXX, *A*.) Some are porous or vacuolated; others appear as nodules of combined mineral and organic matter or semipetrified. Although in medium thin sections they may be opaque, in very thin sections they are translucent. The pyrite nodules present in all coals, are absolutely opaque no matter how thin the section.

The carbonaceous matter seen so characteristically at a magnification of 1,000 diameters, has the same general nature as that seen at lower magnifications. But it should be understood that much of the fine matter, shown in many of the photographs at a magnification of 1,000, and approaching the limit of visibility, is of mineral origin.

RODLETS.

From time to time attention has been called to certain components designated "rodlets" or "needles." In vertical sections, especially in vertical sections for opaque observation at low magnification, these appear as black glistening spots, usually circular or oval, but some are crescent-shaped and some are irregular (Pl. XXII, *A*, and Pl. XXIII.) Plate XXVIII, Plate XXXII, Plate XXXIV, *B*; and Plate XXXV, *A* and *B*, show the rodlets in horizontal cleavage surfaces.

These rodlets usually occur in two different ways, either lodged in the attritus seemingly independent of any woody tissue or structure, or associated with definite structure or anthraxylon pieces of coal.

RODLETS SCATTERED THROUGH THE ATTRITUS.

Although these rodlets are scattered promiscuously through the coal they are particularly abundant in some horizons in the attritus. When a piece of coal is split along a horizontal cleavage plane through such layers, many needlelike bodies, parallel to the bedding plane in every conceivable direction are exposed on both surfaces of the fracture. (Pl. XXXV, *A* and *B*.) The rodlets differ in length and thickness, in various layers and to some extent in the same layer or fracture; that is, in some layers they are all fine, occasionally very fine and of microscopic thickness, but still differing from each other in thickness. In another layer they may be thick and coarse, also varying in thickness within the layer, or again they may be of medium thickness, but thick, thin, and medium rodlets are

rarely found together in one layer. Occasionally they are uniformly thick, some almost cylindrical, others tapering, some straight, others curved, irregularly bent, or crooked; some semicylindrical or roughly so, but all differ greatly in length and seem to be short pieces of longer bodies.

RODLETS ASSOCIATED WITH WOODY STRUCTURES.

When associated with woody structures rodlets are a definite part of the structure, always lying parallel to the woody fibers; in other words, they are a part of the piece of anthraxylous coal in which they are formed. They vary in thickness like the rodlets scattered in the attritus. Their length depends entirely on the size of the piece of the anthraxylon in which they are found. Similar rodlets are found in the so-called charcoal in similar relationship.[a]

CHARACTERISTICS OF THE RODLETS.

The rodlets are nonresinous, do not fuse, and do not swell on heating, and when they burn at all they do not burn with a sooty flame. Their exterior surface is rather rough and dull, but when broken they reveal a smooth, jet black, glistening fracture. They are brittle, and break with a conchoidal fracture. Some are dense and solid, others more or less spongy. They are rich in quartz, and are petrified or semipetrified or composed of a mixture of finely divided organic or coaly matter and quartz. Some, in fact, consist entirely of silicious matter, some having a central core of quartz surrounded by a thinner or thicker coat of semicarbonaceous matter, in some the carbonaceous matter is more or less crescent shaped in cross section. Usually, however, the whole rodlet is composed of petrified matter. The rodlets may be composed wholly of quartz or contain only a small amount, but the proportion of quartz is, on the whole, very high. The rodlets can easily be removed from the coal, and with a hot flame the organic matter may be entirely burned out leaving a snow-white silicious matter, which is of a delicate spongy nature and varies in amount and texture according to the proportion of the original components. When the silicious content is relatively small the structure of the residue is very delicate, and when the silicious content is very high, the residue is solid.

Although many rodlets have exterior markings, no definite organized markings, such as pits, spirals or trabaculae, have been observed on the rodlets. When exterior markings are present they consist of small irregular hollows, irregularly situated. Frequently, however, these are arranged in rows, quite closely packed, resembling pits of tracheae. (Pl. CLVI.)

[a] White, David, Resins in paleozoic plants and in coals of high rank: Prof. Paper 85–E, U. S. Geol. Survey, 1914, pp. 75–76.

THE ORIGIN OF RODLETS.

During the coal-forming period the plants contributing to the coal deposits were chiefly Lepidodendrons, Lygenodendrons and Medullosae. The stems of these plants were woody cylinders or rings of wood or xylem. In the center of the stems in some was a large core of pith, and surrounding the ring of wood was a thick cylinder of cortex consisting mainly of a pith-like tissue. In the stems of others, as Heterangium Grievii, there was no pith, but the whole central part was occupied by a vascular or woody cylinder composed throughout of irregular anastomosing groups of tracheae, interspersed with strands of parenchymatous or pith-like tissue; and the central cylinder of wood was surrounded by a thick cortex.

In other forms, as the Medullosae, several, usually three, solid vascular cylinders, close together were surrounded by a common cortex, (Pl. CLI, *A*). In all of them the wood was divided into wedges by broad rays consisting of parenchymatous tissue. The cortex of all these forms was pervaded by numerous leaf traces. Strands or bundles of vessels issuing from the vascular cylinders would turn upward before entering the leaves, run up into the cortex a considerable distance and finally run outward into the leaves. In some of these forms the cortex was traversed by numerous mucilage canals, that closely resembled the mucilage canals of the living cycads. A correct idea of the structure of these stems may best be obtained by examining the stem of a fossil Medullosa. Plate CLI, *A*, represents a cross section of the stem of Medullosa anglica, the only stem so far found in this country. In the central part of the stem the three vascular cylinders, each with its central primary wood are visible (px). Inclosing the three vascular cylinders is a common periderm (p), outside of this is the inner cortex (ic) and surrounding this again is the outer cortex (oc). Although the cortex of this specimen was much disorganized and pyritized, both the mucilage canals and the leaf traces may be distinguished. Plate CLI, *B*, Plates CLII, and CLIII, are radial sections through the cortex and part of one of the steles of the same stem, showing the mucilage canals (m) and the leaf traces (lt) in the parenchyma (ic). At (oc) may be observed sclerenchymatous strands in the outer cortex.

In Plate CLIV, *A* and *B*, both showing coal from Shelbyville, there is a very close resemblance to the appearance of the radial sections of the Medullosa stems. The lighter parts (p) are clearly shown to be parenchymatous tissues; in this are embedded vascular strands (vs), closely resembling the vascular strands of leaf traces in the fossil Medullosa, and slender needle-like bodies (m) that closely resemble the contents of the mucilage canals of the same specimen. These needlelike bodies resemble in every particular the

rodlets found throughout the coals. Similar woody patches are common in almost every coal. Woody components containing rodlets are evidently not all of the same species, as a number of different types contain rodlets.

Plate CLV shows a woody patch from the Zeigler coal. In this specimen the vascular tissue consists of rather broad bands (vs), whereas the parenchymatous tissue consists of comparatively narrow strands (p). In this specimen the needles or rodlets are in the vascular strands. Some rodlets are embedded in the parenchymatous tissue as far as can be determined by the pieces left.

Several types, apparently different, are found, but details concerning them is unnecessary. Enough has been shown to reveal the identity of some of the rodlets and to show that the mucilage canals of the Medullosæ and related forms are one source of rodlets.

FUNGI.

Bodies resembling the hyphæ and spores of fungi have been found in all of the coals examined. Fungi have positively been identified in the coal from the Vandalia mine. (Pl. CLVII, *A* and *B*.) The hyphæ are found only in the anthraxylon strips, which in some sections are densely crowded with them. Their habits seem to have been much like those of certain fungi that infest the wood of recent plants. The hyphæ run largely parallel to the fibers of the wood, and presumably in the lumina, but penetrate the walls of the fibers at right angles (Pl. CLVII, *A*), a characteristic habit of recent fungi. Frequently they radiate irregularly from a common center. (Pl. CLVII, *B*.) Sporelike thickenings are often observed, as shown in the photographs just referred to, and are similar to those found in woody peat.

Sporelike bodies have been found associated with spore-filled sporangia in the coal of the experimental mine. A part of such a sporangium is shown in Plate CLVIII, *A*, at a magnification of 150 diameters, the sporelike bodies being visible among the spore-exines. Plate CLVIII, *B*, and Plate CLIX, *A* and *B*, taken from different parts of the sporangium at a magnification of approximately 1,000 diameters, show the same bodies more distinctly. The tissue of the sporangium is well preserved on one end and almost lacking on the other. On the latter end are numerous indefinite threadlike bodies, presumably hyphæ. The sporelike bodies occur in largest numbers in the semistructureless region, as shown in the photographs. The evidence is not sufficient for a positive conclusion, but the bodies in question probably are fungi.

OTHER ORGANISMS IN COALS.

Other bodies that deserve notice are shown in Plate CLX, *A* and *B*. These are of an unknown origin, and their general nature may best be learned from the photographs. The individual body is rounded, but slightly wedge-shaped, and a number of these, either 9 or 10, often form a complete ring. Others are scattered separately through the section. The organism is exceptionally small, the ring measuring between 7 and 9 microns and the individual bodies about 2 microns in diameter.

COMPARISON OF THE STRUCTURES OF THE COALS.

THE COALS FROM THE PITTSBURGH SEAM.

The coals examined from the various localities from the Pittsburgh seam, have similar structure and composition, and their constituents are of similar origin. There is a slight difference in the proportions of the various constituents, also in the general appearance, color and opaqueness, physical condition and chemical nature of the coal in the different localities. The latter is especially noticeable in comparing coals from the western and eastern parts of the field. This concerns the physical and chemical nature of coal, and is mentioned incidentally.

Of the coals examined from the Pittsburgh bed, that from the Oak mine and the experimental mine are nearest alike. That from Madison and the so-called Pittsburgh coal, picked up from coals delivered in Pittsburgh for domestic purposes, differ from the Oak mine and the experimental mine coals in that the attritus is richer in carbonaceous matter and the anthraxylon is slightly less translucent and is darker red. However, in thin sections the anthraxylon is vitreous, clear, and transparent in all four coals. The attritus in the Madison and the Pittsburgh coal appears darker on account of the large proportion of carbonaceous matter. In sections or layers of the coal where the carbonaceous matter is absent, the attritus looks like that of the other two coals.

The coal from the Connellsville region is markedly different from the others. Its anthraxylon is a much darker red and far less translucent. The difference between the various anthraxylon strips, so plain in the other coals, has been lost and the strips can be distinguished from one another only with great difficulty. The greatest difference exists in the attritus. In a casual microscopic examination and even a fairly careful examination, the attritus seems to contain no spore-exines nor resinous matter and to be composed of humic matter only. In a close and careful examination, evidently the spore-exines at one time were in exactly the same proportion as

in the other coals, but in some way have been largely eliminated. Only a few whole spores are faintly recognizable; usually only residues or vacant places are seen where were once spore-exines. The humic matter has become more opaque and can not be detected from the resinous matter.[a]

The Connellsville coal has not been exhaustively studied, but its original composition clearly was much like that of Pittsburgh coal and the coal from other localities. Also, the spore-exines still remaining are of the same type as those from other parts of the bed.

THE COAL FROM CARBON HILL, ALABAMA.

The coal from Carbon Hill is more like the normal coal from the Pittsburgh bed than any other coal examined, but the predominant spore-exines differ from those of the Pittsburgh coal or those of any of the other coals examined.

The most striking characteristic of the Carbon Hill coal is the relatively large proportion of well-preserved tissue among the smaller anthraxylon components. Such chips as are shown at 6–a in Plate LXXXIV and 4–a in Plate LXXXV are common in every section. The anthraxylon strip at 1–a, Plate LXXXVII, is more homogeneous and much more compressed. Nevertheless, the cell structure was clearly discernible under the microscope and is recognizable to some extent also in the photograph.

The humic matter shown at 1–d to 3–d in Plate LXXXIV and in the whole of Plate LXXXVI is greatly comminuted and a relatively little spore matter and carbonaceous matter is present. Plate LXXXVIII, *B*, an area included in Plate LXXXVIII, *A*, at a magnification of 1,000 diameters, represents the groundmass of the attritus in which the spore-exines and other smaller constituents are embedded. Most of the spore-exines are relatively large and thin-walled; only a few seem to be small and thick-walled. The groundmass as shown in Plate LXXXVIII, *B*, is largely granular; it consists of carbonaceous, earthy, and humic matter, besides a substance resembling spore matter which probably is the degradation product of cuticular matter.

It should be remembered that the particles or objects represented in such photographs are exceedingly minute. For instance, no spore-exine shown in this photograph is more than 3 microns, or 0.003 mm., thick. The groundmass shown in other sections may consist of carbonaceous and earthy matter and a larger proportion of "humic" matter, or may be derived from the woody parts of plants, some of it in the shape of small fragments or particles and some approach-

[a] The truth of this statement is still under investigation and will be discussed more fully in a paper on "Differences of coking and noncoking coals," now in preparation.

ing an amorphous state. The photographs show also a matter lighter in color intermixed with the others.

THE ILLINOIS COAL.

In structure and general appearance the Illinois coal differs considerably from the Pittsburgh coal. The former has a far greater number of the larger anthraxylon components, much less of the highly carbonized matter, and a smaller proportion of the attritus. Consequently the anthraxylon components are more closely packed, often piled one immediately upon the other, without any of the other constituents that usually form part of the attritus separating them, although they are usually separated by thin layers of spores or by cuticular matter. The different pieces of anthraxylon, being but poorly differentiated in color or other characters, are not always readily distinguished from one another under the microscope. Cuticles, which form but a very small part of the Pittsburgh coal, are prominent in these coals, and another tissue, consisting of light-colored, thick-walled, irregularly folded cells, usually associated with cuticles and found only rarely in the Pittsburgh coal, is also prominent in the Illinois coals. Such a tissue is well shown at 3–d, Plate XCII, *B;* at 3–d and 4–d; Plate XCIII, *B;* Plate XCIV, *A* and *B;* Plate CX, *A;* and at a very high magnification in Plate CX, *B*.

THE ZEIGLER COAL.

The photographs of the coals from the Zeigler mine well illustrate the group. Plates XCII to XCVII give typical cross sections from the Zeigler coal. Plate XCII, *A*, represents an anthraxylous strip in which the original tissue is greatly compressed and rendered homogeneous, yet inclusions in the cells are distinctly recognizable at the region 5–a. At 1–a a number of thin strips have been intimately united; at 3–a is a woody tissue containing pale, flattened cells. The rounded and irregular black spots that are particularly abundant and noticeable in the upper part, 1–a, are pyrite nodules. These nodules readily break into numerous fine particles, and in the process of making the section are often scattered across it in streaks, which are prominent in the photographs.

At 1–a in Plate XCII, *B*, is shown a bit of anthraxylon characteristic of this group. The original cells are compressed into very thin, straight striae. In a horizontal section the woody structure is distinctly recognized as seen in Plate XCIX, *B*. The remainder of Plate XCII, *B*, represents a strip of coal composed of woody and resinous matter arranged in thin sheets alternating with cuticles, spore-exines and the remains of a tissue of pale, irregularly folded cells mentioned in the preceding paragraph. This tissue is particu-

larly well represented at the level 3–d, but is also visible in other parts of the photograph. A similar layer is represented in Plate XCIV, *A*. It is here more irregularly layered and present in larger proportion. This tissue resembles the cork layers in bark, and is termed cork-like or corky tissue, although its origin has not been definitely determined. Leaf cuticles are also prominent, whereas spore-exines are relatively few. The anthraxylon matter, 2–a, is seen compressed into straight striae.

Plate XCIV, *B*, shows another characteristic appearance of these coals. Anthraxylon, cuticles, corky tissues, spore-exines, and resins are all represented. Plates XCV and XCVI and CV, *B*, represent, at a magnification of about 1,000 diameters, areas included in the section shown in Plate XCIV, *B*. Plate XCV, *A*, is an enlarged area in the middle of the level 1–d, of Plate XCIV, *B*. The white areas across the middle of the photograph represent the cork-like tissue. Carbonaceous matter, at the top, woody matter, and thin spore-exines are all readily distinguishable. Plate XCV, *B*, represents an area included in Plate XCIV, *B*, in the middle of the level 6–d. Spore-exines, cuticles and anthraxylon matter are distinguishable. The cell structure of the anthraxylon component in the lower part of the photograph, a part of the anthraxylon component at 7–a, of Plate XCIV, *B*, is here shown at higher magnification. Plate XCVI, *A*, at a magnification of 1,000, is taken from the same section, but just outside of the area represented by Plate XCIV, *B*. Plate XCVI, *B*, and Plate CV, *B*, at 1,000 diameters, also from the same section, show in cross section the thick-walled spore-exine sparingly represented in these coals, but predominant in the Sesser coal. Plate XCVII, *A*, magnified 200 times and Plate XCVII, *B*, magnified 1,000 times, from an area included in the former, show considerable resinous matter besides the usual constituents. The area 2–sp of Plate XCVII, *A*, explains the striated appearance seen at low magnifications in Plate XXIV, *A*. This is much better illustrated in Plate XCVIII, *A* and *B*, magnified 200 times, representing laminæ largely composed of the residue of leaves and leaf cuticles. The heavy, more or less zig-zagged white lines represent the cross sections of leaf cuticles, and the matter between them, largely the residue of leaf tissues.

THE HART-WILLIAMS COAL.

So far the normal appearances of these coals have been shown. Certain layers are found that are chiefly composed of spore-exines and more highly carbonized matter. Such a layer is shown in Plate LXXXIX, *A*, magnified 200 times, from coal from the Hart-Williams mine. Plate LXXXIX, *B*, magnified 1,000 times, represents an area included in the former. The fine, scattered, highly car-

bonized matter is distinctly shown in this latter photograph, and the humic or anthraxylon matter is also resolved into finer particles. At the bottom, the strip of anthraxylon about 15 microns thick is solid, but still shows evidences of cell structure.

THE SESSER COAL.

In certain respects the Sesser coal differs considerably from the coals just discussed. The anthraxylon components are more comminuted and contain considerably more resinous and carbonaceous matter and fewer spore-exines and cuticles. Woody structure is preserved about as well as in the coals of the Hart-Williams, Benton, and Zeigler group. A heavy-walled spore-exine distinctly predominates but is not found in this coal exclusively.

A characteristic appearance of the Sesser coal is shown in Plate CIII, *A*, magnified 200 times. At the area 1–d is a considerable amount of resinous matter, some humic matter more or less comminuted, and a few spore-exines. The anthraxylon strips 2–a and 4–a include a thin sheet comprised of a tissue several cells thick of definite and well-preserved plant cells. The woody layer at 6–a also shows more or less cell structure, much obscured. Plate CIII, *B*, and Plate CIV, *A*, both magnified 200 times, also are characteristic. A considerable proportion of the matter shown is clearly of woody origin, as indicated by the fine striations, which are a sure criterion of a woody origin, especially when seen at higher magnifications. Much of the comminuted matter looks quite homogeneous under ordinary microscopic examination, a characteristic of resinous matter. However, resinous matter usually is rounded or oval, whereas the matter shown here is decidedly angular. More highly carbonized matter may be noticed scattered throughout the coal, but relatively little spore matter is visible. Plates CIV, *B*, and CV, *A*, represent small areas of this coal at a magnification of 1,000 diameters; the predominant thick-walled spore-exine is embedded in an anthraxylous débris mingled with some carbonaceous and some earthy matter.

THE ROYALTON COAL.

The Royalton coal, although in general much like the other Illinois coals, differs from them in certain respects. Its anthraxylon components reveal well-preserved cell structure; much of it exceptionally well preserved. Its spore-exine content is a little higher than in the Hart-Williams, Benton, and Zeigler group, and it contains more highly carbonized matter. Its chief characteristic is its broad, relatively thin, anthraxylon components, or chips, which are often separated by definite sheets of attritus, and give the cross section under the microscope a shredded look. Cuticles are abundant in some

layers, and accompanying them are the pale-thick-walled, irregularly folded and layered cells predominant in the Zeigler coal. (Pl. CX, *A* and *B*.)

The photographs illustrating the coal from this section have been chosen from a wide range of samples, and like those of other coals, are intended to represent general conditions.

Plate CVI, *A*, is a layer rather rich in spore-exines and finely comminuted humic matter, with some resinous-looking matter scattered through it. The cross section of the anthraxylon chips at 4-a is characteristic. Plate CVI, *B*, shows a strip of anthraxylon with remarkably well-preserved tissue. Similar strips are quite prevalent in this coal. Resinous bodies may be observed in the level 1–d.

Plate CVIII, *B*, at a magnification of 1,000 diameters, represents a more highly magnified portion of Plate CVIII, *A*, in the level 3–d. The spore matter consists both of whole spore-exines and of fine fragments, the latter being common, though not prevalent. The anthraxylon strips, although very thin, still show some cell structure. Plate CIX, *A*, shows considerable opaque carbonized matter interlayered with the anthraxylon strips. Plate CIX, *B*, a more highly magnified portion of the section included in Plate CIX, *A*, at the level 2–a, shows the remains of woody structure that prevail everywhere. On casual observation the anthraxylon strips represented in these photographs seem homogeneous, but at higher magnifications and proper lighting and screening the structure is brought out clearly. The irregular bands in Plate CIX, *B*, show matter rendered dark by earthy and carbonaceous matter intermixed.

Much of the Royalton coal reveals the same general appearance as the Zeigler coal, as shown in Plate CX, *A* and *B*, and needs no further discussion.

THE BUXTON (IOWA) COAL.

The general nature and structure of the coal from Buxton, Iowa, is shown in Plate CXXI, *B*, and Plate CXXII, *A*. Some horizons are woody and contain few spores, others are woody and resinous, others contain a large proportion of spore-exines and relatively little woody matter, and still others contain a large proportion of spores mixed with much earthy matter or with carbonaceous or resinous matter. This coal also contains numerous minute nodules of pyrite, so irregularly distributed that some thin laminæ are composed chiefly of them, while other laminæ contain few. Cuticles also form a large proportion in this coal, anthraxylon sheets and cuticles alternating in close succession in many layers.

Plate CXXIV, *A*, shows a characteristic layer of cuticles, anthraxylon, and resinous matter. Plate CXXXVI, 5, shows how many of the isolated cuticles look. Plate CXXIV, *B*, shows layers

of débris containing a few spores, a large proportion of finely comminuted anthraxylon or humic matter, and a medium proportion of earthy and carbonaceous matter. In 3–sp is a part of a sporangium, with well-preserved cell structure, inclosed in a cuticle, and containing a few spore-exines in the central part. Plate CXXV, *A*, shows an area containing a large proportion of resinous matter, besides strips of anthraxylon matter, comminuted anthraxylon matter, spore-exines, and earthy and carbonaceous matter. In Plate CXXV, *B*, are the same elements, but the earthy and carbonaceous matter form a very large proportion. Plate CXXVI, *A*, shows a more anthraxylous section, common in this coal. At the upper part at 1–a is part of a thicker piece of anthraxylon. Plate CXXVI, *B*, contains anthraxylon strips and intercalated resinous layers, a feature characteristic of this coal and of the coal from Vandalia, Ind.

The black irregular and circular spots scattered through this photograph represent pyrite nodules, such as occur from top to bottom of the bed. In Plate CXXVII, *A*, the layers consist chiefly of spore-exines, but also contain much earthy and carbonaceous matter which is characteristic of many layers in this coal. The spore-exines so numerous in the photograph are the predominant spores throughout this seam. The cross sections of the spore-exines are better seen in Plate CXXVII, *B*, magnified 1,000 times and taken from a section included in Plate CXXVII, *A*. Plates CXXVIII, *A* and *B*, and Plate CXXIX are characteristic appearances of the Buxton coal in horizontal sections. The first two show much woody matter, the cell structure of which is plainly seen. Plate CXXIX, *A*, represents a portion through the attritus, showing spore-exines, humic matter, and carbonaceous matter. Plate CXXIX, *B*, is a more highly magnified portion of Plate CXXIX, *A*.

Sporangia, filled with spores and well preserved, often with the sporangium wall intact, are common in the Buxton coal (Pls. CXXI and CXXII). Whole cones, or parts of cones, in which are sporangia filled with spores still intact, are also common.

The anthraxylon components of the Buxton coal are clearly differentiated from one another by their colors; they are resinous and have a relatively coarse physical texture or loose micellar structure. The pieces are mostly flat and thin, but thicker and less numerous than in most coals. These characteristics are well shown in the photographs.

In cross section the cell structure of the anthraxylon matter does not seem to be well preserved, only occasionally are strips found in which the structure is clear, yet evidences of the cell structures are seen everywhere. In the horizontal sections, however, the cell structure is evident in every section. (Pls. CXXVIII, *A* and *B*.) Plants with large cells seem to have played a prominent part in the formation of this coal, as it contains large isodiametric parenchy-

matous cells. The cell walls are very much compressed and they now appear thin and poorly defined. It would seem that the decay of the wood had advanced far during the peat stage.

THE VANDALIA (IND.) COAL.

A casual examination of the Vandalia coal from Vigo County, Ind., in the block (Pl. CXLII), shows that it contains few of the larger anthraxylon pieces. For example, a lump of coal, about 10 inches thick, under examination contains only one anthraxylon layer about one-fourth of an inch thick, and only four or five pieces between one-eighth and one-fourth of an inch thick. More careful examination shows that the remainder of the coal is composed of innumerable thin sheets of anthraxylon, and that most of these are much less than an eighth of an inch thick, many of them being microscropic. The general nature of the components has already been shown by a cross section at low magnification and from horizontal cleavage planes. Horizontal cleavages expose patches of woody structure of a variety of sizes and shapes; although in many patches the pieces seem to be relatively long and broad, by far the largest number are less than an inch wide and long. (See Pls. XXV, XXVI, and CXLIII, *A* and *B*.) Examined in opaque cross sections at lower magnification the coal is seen to contain relatively little microscopic débris, or attritus (Pl. CXLIII, *A* and *B*), the bulk being composed of closely packed anthraxylon matter.

Examined in cross section at a magnification of 200 diameters (Pls. CXLVI to CL) the coal is seen to be composed of innumerable, closely packed, thin pieces of anthraxylon matter with relatively little of the fine microscopic matter or attritus; hence it contains relatively few spores. A dearth of spores is a characteristic of this coal.

Plate CXLVI, *A*, is a typical section. In the upper part, at 1–a, is a relatively thick piece of anthraxylon; at 2–c is a layer containing a number of very thin cuticles; at 3–d are thin anthraxylon strips with carbonaceous matter, including an occasional spore-exine between; at 4–a is a sheet of light-colored anthraxylon matter that shows cell structure faintly; and at 5–d is a thin layer consisting of anthraxylon strips with included carbonaceous matter and some earthy matter that give a dark color. The round and irregular black spots represent nodules of pyrite, common in this coal.

Plate CXLVI, *B*, is another typical appearance of the Vandalia coal; the anthraxylon strips at 1–a and 4–a, and attritus at 2–d, 3–d, and 5–d, contain a large proportion of spore-exines lodged in dark, macerated humic matter.

The anthraxylon throughout the coal is very resinous, and layers like those shown in Plate CXLVII, *A* and *B;* Plate CXLVIII, *A*

and *B*, and Plate CXLIX, *A*, are common. Particularly common are anthraxylon components containing numerous resinous globules similar to those shown in Plate CXLVII, *B*, CXLVIII, *A* and *B*, and Plate CXLIX, *A*, though usually with more of the original woody matter remaining than here shown. In the piece represented in Plate CL, *A*, much of the woody matter remains characteristically associated with the resin globules in situ; in other sections, as in Plate CXLIX, *A*, at 1–a, the remaining anthraxylon matter seems to have rotted away partly, leaving little else but the resin, which is partly intact. Plate CXLIX, *B*, is an example. So completely has the woody tissue disappeared that the interstices between the resin particles are merely empty spaces.

When examined in cross section little of the original cell structure is clear; nevertheless evidences are seen by careful examination under proper lighting. In the horizontal sections, the structure may be recognized easily, as in Plate CXLV, *A* and *B*, though in places it is difficult to detect.

The anthraxylon of the Vandalia coal has a loose micellar structure, as the photographs indicate, and is not as compact as that of the Pittsburgh coal. In this respect the Vandalia coal resembles the Buxton coal. The mottled appearance in the anthraxylon strips, 1–a, in Plate CXLVI, *A*, and 1–a and 4–a in Plate CXLVI, *B*, is due to this loose structure. If the photographs of the Pittsburgh coal are compared with them, the differences are readily seen. The Pittsburgh coal has a glassy and the Vandalia coal a spongy appearance.

PLATES I–CLX.

PLATE I.

KIEL PEAT BOG.

A. A bird's-eye view, from the east, of the peat swamp near Kiel, Wis. The foreground, an expanse of about 1 mile drained by the Sheboygan River, is now cleared of trees and is covered with shrubs, grasses, and sedges. The wooded peat swamp lies beyond this open area. The highland rising beyond the wooded swamp is 3 miles distant.

B. A near view of the interior of the same peat swamp. The trees are chiefly white cedar (*Thuya occidentalis*), with here and there a tamarack (*Larix americana*) and a black ash (*Fraxinus nigra*). The hollows in the foreground are filled with water.

PLATE II.

NEAR VIEWS OF PEAT BOGS.

A. A view in a peat swamp in Charlestown Township, Calumet County, Wis. The growth consists primarily of the same plants as that in the swamp shown in Plate I, *B*.

B. A view in a peat swamp in Eaton Township, Manitowoc County, Wis. Notice the uneven surface of the ground, density of the growth and the reclining positions of a number of trees.

C. A view in another part of the Eaton swamp in which the growth consists largely of young trees.

PLATE III.

NEAR VIEWS OF PEAT BOGS.

A. A near view in the swamp near Kiel, Wis., shown in Plate I, *B*. The surface is covered with dead branches, twigs, leaves, and bits of wood.

B. A perpendicular view of the surface, a short distance from that shown in *A*. The litter on the surface consists largely of the leaves of the white cedar (*Thuya occidentalis*), leaves of deciduous trees and shrubs, and twigs and fragments of wood.

PLATE IV.

A LUMP OF PEAT FROM A WOODY SWAMP.

A. Natural size. A lump of peat showing small fragments of wood and some cuticular matter embedded in the finer débris.

B. A small area, more highly magnified, between the fragments of wood of a lump of peat similar to the one shown above.

PLATE V.

SMOOTHED SURFACE OF A LUMP OF PEAT.

A horizontal smoothed surface of a lump of peat (×10), showing bits of wood, seeds, and small bits of cuticles all embedded in the attritus.

PLATE VI.

CHIPS OF WOOD FROM PEAT.

Small fragments of wood separated from the lump of peat shown in Plate IV, *A*. Most of these pieces have been formed through exfoliation along the growth rings or through separation along the rays, are thin, flat chips that are hard when dried.

PLATE VII.

CROSS SECTIONS OF WOODY PEAT.

A. Cross section of one of the small fragments of wood shown in Plate VI. (×200.) The cells of the wood have collapsed during drying, and the walls have become contorted and folded.

B. Part of the same section shown above (×1,000), showing the nature and form of the cell walls, and a few of the organisms found in peat.

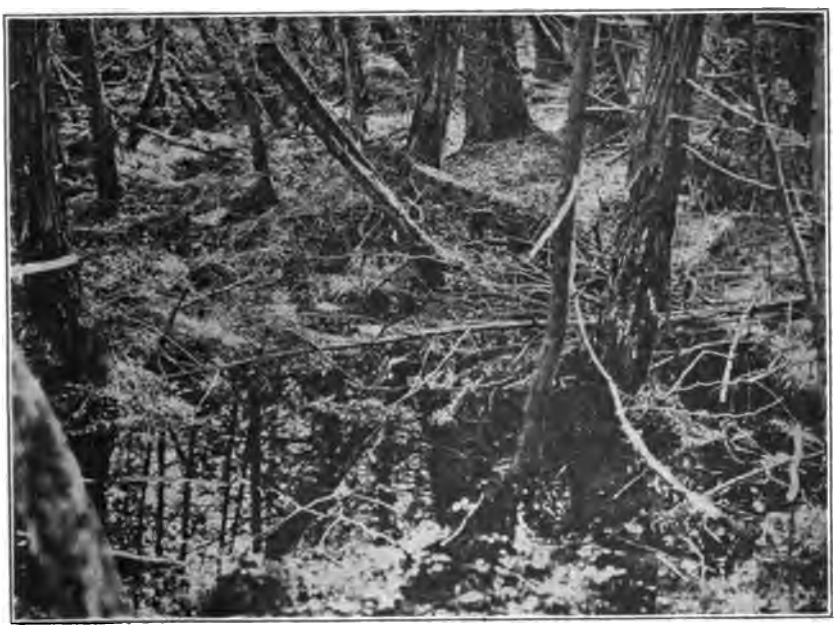
PLATE VIII.

ORGANISMS IN WOODY PEAT.

A. A lamina one cell thick (×1,000), from fragment of wood shown in Plate IV, *A*, showing the granular nature of the cell walls and certain large organisms prevalent in the woody peat.

B. Spores of a living ground pine (*Lycopodium clavatum*). (×1,000.) Note the relatively thick outer spore walls, or exines, covered with blunt spines.

A. PEAT BOG NEAR KIEL, WIS.



B. NEAR VIEW OF BOG NEAR KIEL, WIS.

A. NEAR VIEW OF PEAT BOG IN CALUMET COUNTY, WIS.

B. NEAR VIEW OF PEAT BOG IN MANITOWOC COUNTY, WIS.

C. ANOTHER VIEW OF THE BOG IN MANITOWOC COUNTY, WIS.

A. CLOSE VIEW OF THE BOG NEAR KIEL, WIS.

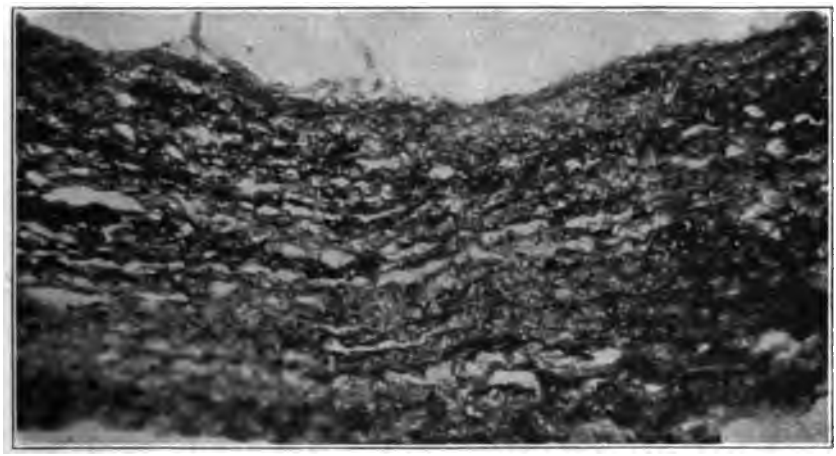
B. PERPENDICULAR VIEW OF SURFACE OF BOG NEAR KIEL, WIS.

A. LUMP OF PEAT, NATURAL SIZE.

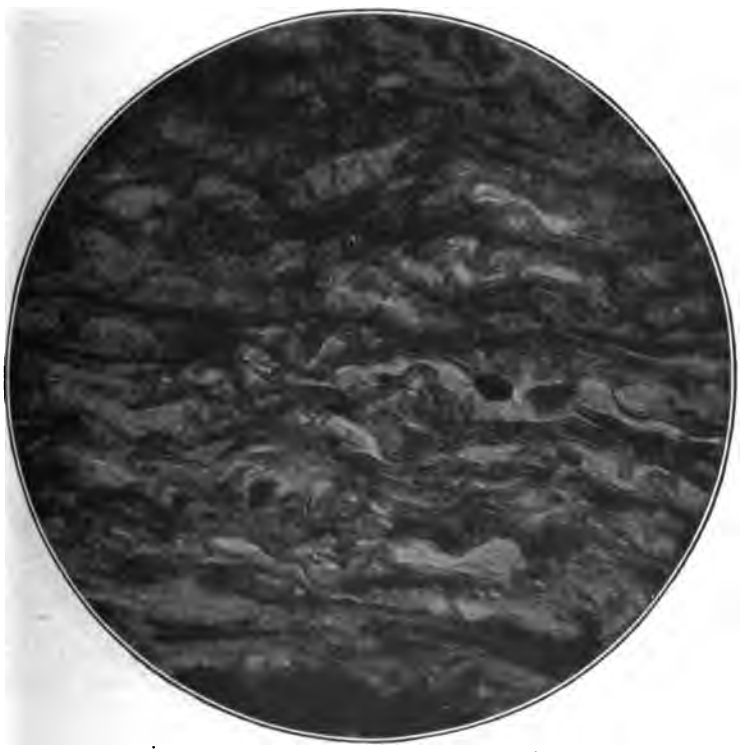
B. MAGNIFIED AREA OF LUMP OF PEAT.

SMOOTHED SURFACE OF A LUMP OF PEAT. (X 10)

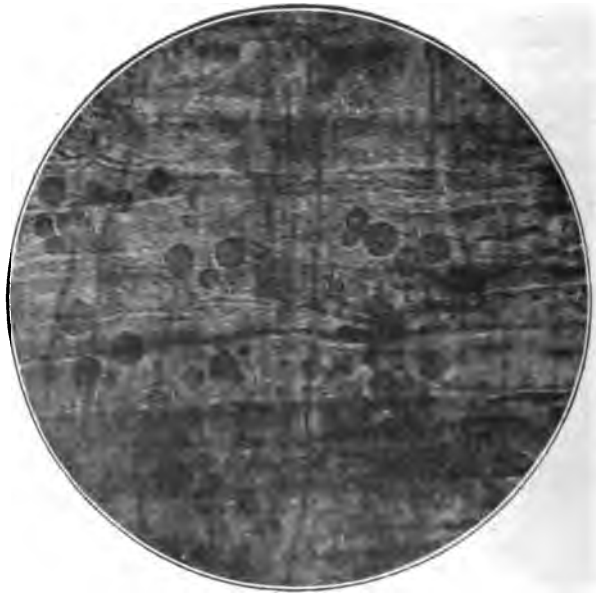
CHIPS OF WOOD FROM PEAT.



A. CROSS SECTION OF WOODY PEAT. (X 200)



B. CROSS SECTION OF WOODY PEAT. (X 1000)



A. ORGANISMS IN WOODY PEAT. (X 1000)

B. SPORES OF A LIVING LYCOPODIUM. (X 1000)

PLATE IX.

CUTICLES OF A CYCAD LEAF AND PINE NEEDLE.

A. Part of the cross section of the leaf of a living Cycad (×100) showing the general structure of the leaf. c, upper cuticle; h, hypodermal tissue; p, palisade cells; pa, leaf parenchyma; s, lower hypoderm containing stomata; c′, lower cuticle, very thin.

B. Part of a cross section of a living pine "needle," (×100.) Notice the conformation of the cuticle, c–c, to the underlying hypodermal tissue, h–h.

PLATE X.

LUMP OF COAL FROM SESSER, ILL.

A chunk of the coal from Sesser, Ill., showing the general laminations into "dull" and "bright" coal and the further sublamination of the "dull coal"; a is the bright coal or anthraxylon components; x–y, the region in which the cleavage plane, shown in Plate XXX, is split.

PLATE XI.

LUMP OF COAL FROM BENTON, ILL.

A. A piece of coal from the mine of the Benton Coal Co., near Benton, Ill., showing the general nature and lamination. a is the bright coal or anthraxylon components; x–y, the level of the horizontal fracture, fracture 1, shown in Plate XXVIII, *A*; t–u the level of fracture 2, shown in Plate XXVIII, *B*.

B. The opposite side of the piece of coal shown in *A*. y–z indicates the level of fracture 1, shown in Plate XXVIII, *A*; u–v, fracture 2, shown in Plate XXVIII, *B*.

PLATE XII.

LUMP OF COAL FROM BENTON, ILL.

A piece of coal from the mine of the Benton Coal Co., representing a more "woody" or anthraxylous layer, as well as showing the general nature and lamination into the "dull" and "bright" coal, a represents "bright" coal or anthraxylon; d, "dull" coal; 1–a to 7–a and 2–d to 8–d indicate the "bright" and the "dull" coal, respectively, in the area cut off by the lines x–x, y–y, n–n, and m–m, and shown in Plate XV, from a polished surface. (Natural size.) co is part of a cone shown in Plate XIV. (Natural size.)

PLATE XIII.

LUMP OF COAL FROM BENTON, ILL.

The opposite side of the same block is shown in Plate XII. d is "dull" coal; a, "bright" coal; co is a part of the same cone shown in Plates XII and XIV.

PLATE XIV.

CONE IN THICK VERTICAL SECTION.

An opaque cross section (×10), viewed by reflected light, of coal from the mine of the Benton Coal Co.; 2–co is part of an embedded cone shown in Plates XII and XIII, co. The lighter lines are the sporangium walls; the thicker gray lenses are a mass of spore exines; the irregular lines in black are part of the sporophyll tissues; 3–a is a thicker anthraxylon component, and 1–d, a layer of débris not clearly differentiated in the illustration.

PLATE XV.

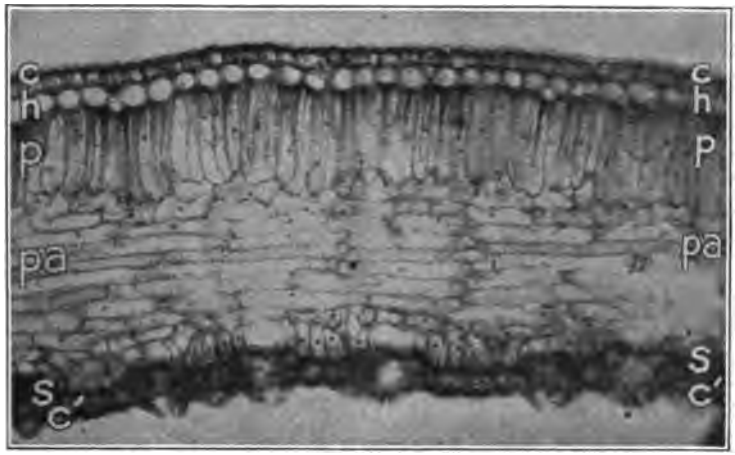
A MAGNIFIED AREA FROM PLATE XII.

Polished area (×10) mapped out by the intersecting lines x–x, y–y, n–n, and m–m, on the face of the block of the Benton coal shown in Plate XII, photographed by means of oblique illumination; 1–a, 3–a, 5–a, and 7–a are "bright coal" or larger anthraxylon; 2–d, 4–d, 6–d, and 8–d are "dull coal"; c is mineral charcoal.

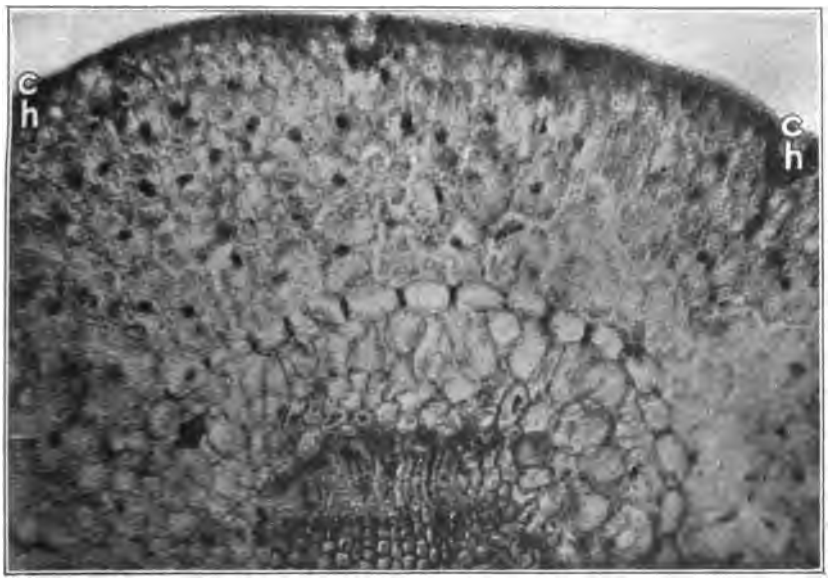
PLATE XVI.

A MAGNIFIED AREA FROM PLATE XIII.

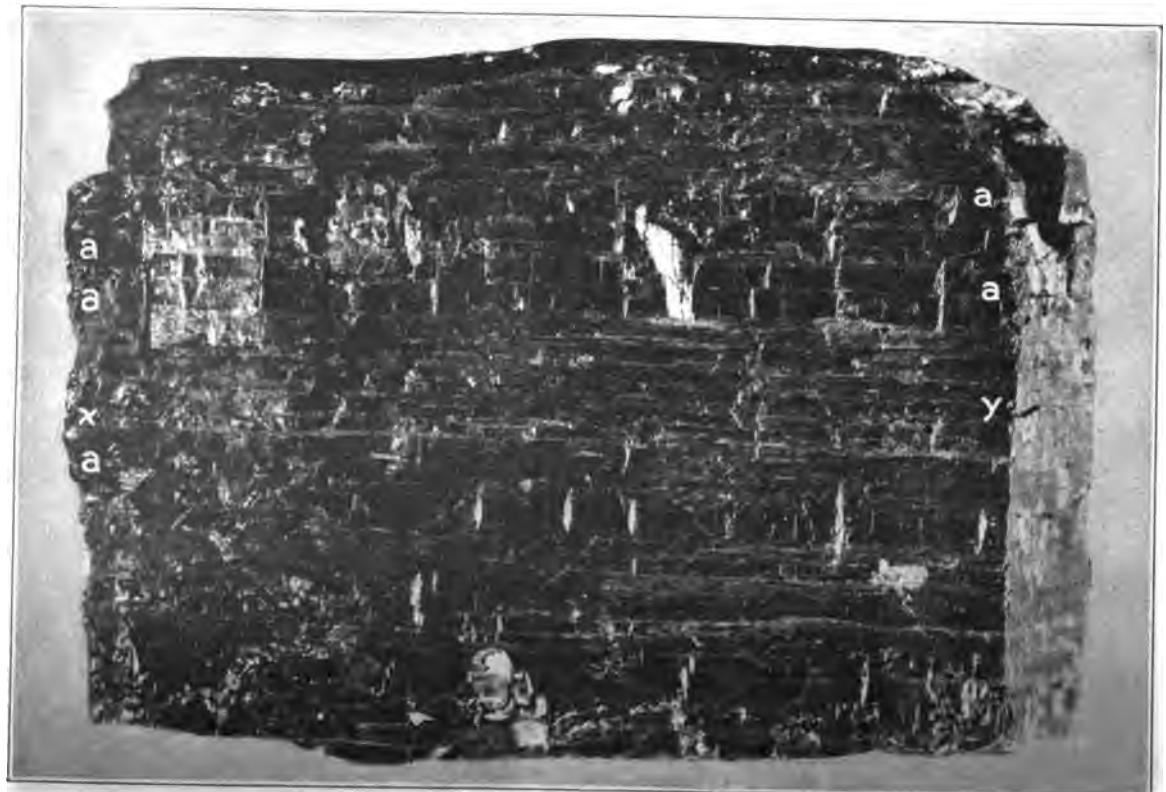
Area (×10) of the Benton coal shown in Plate XIII. a, "bright coal"; d, "dull coal"; ms, a cross section of a megaspore.



A. CROSS SECTION OF A LEAF OF A LIVING CYCAD. (X 100)



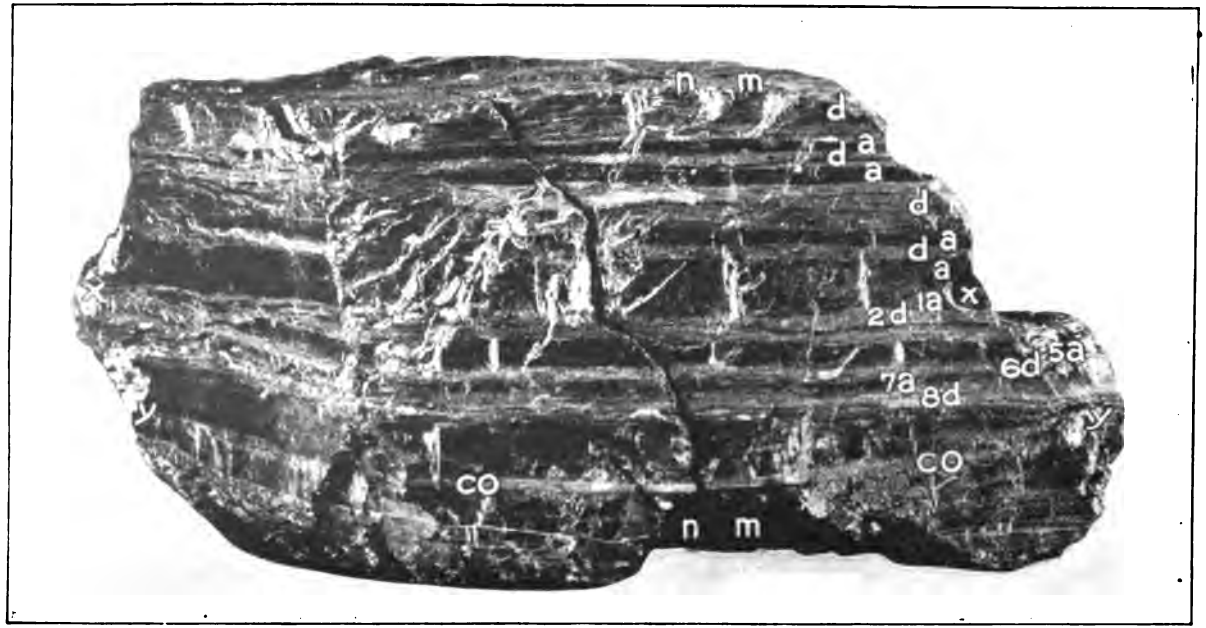
B. CROSS SECTION OF A LIVING PINE NEEDLE. (X 100)



LUMP OF COAL FROM SESSER, ILL.

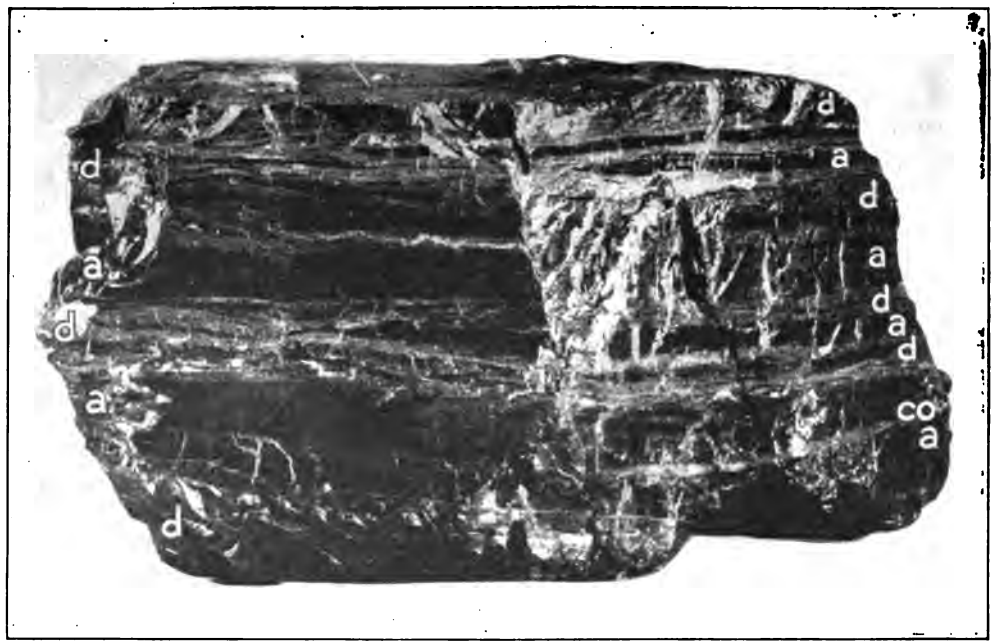
A. LUMP OF COAL FROM BENTON, ILL.

B. OPPOSITE SIDE OF LUMP SHOWN ABOVE.



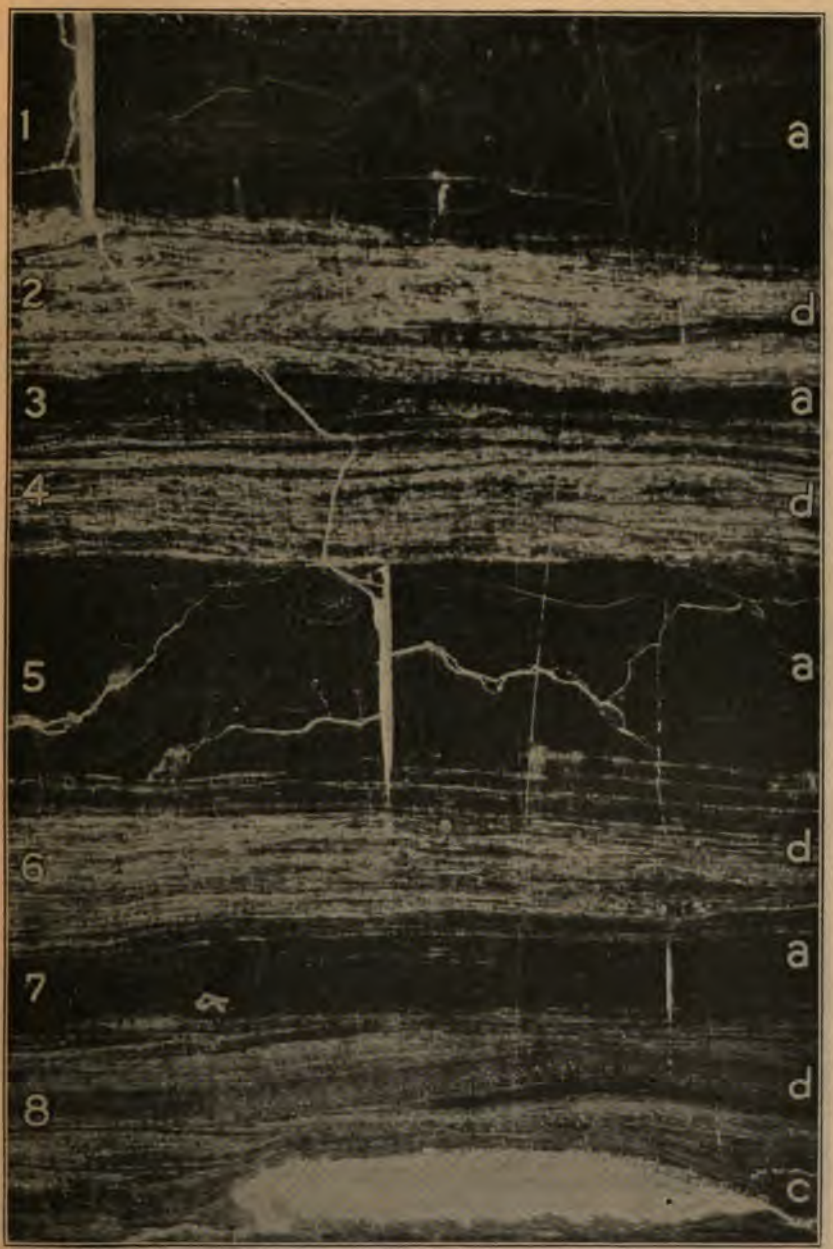
ANTHRAXYLOUS LUMP OF COAL FROM BENTON, ILL.

125536°—20—Bull. 117—9



ANOTHER VIEW OF LUMP SHOWN IN PLATE XII.

CONE IN COAL FROM BENTON, ILL. (X 10)



A MAGNIFIED AREA FROM PLATE XII. (X 10)

A MAGNIFIED AREA FROM PLATE XIII. (X 10)

PLATE XVII.

OPAQUE VERTICAL SECTION.

A continuous area of about ½ by 3 inches of a cross section of a piece of coal from Royalton, Ill. (×10), prepared by reflected light from an opaque polished surface perpendicular to the bedding plane, and showing the embedding matrix, the attritus, and further lamination of the "dull coal" into thinner lenticular laminæ of "bright coal" or anthraxylon. 1–a, 3–a, 5–a, and 7–a are "bright coal" or anthraxylon; 2–d, 4–d, and 6–d, "dull coal"; h–h is the remains of a hollow stem.

PLATE XVIII.

OPAQUE VERTICAL SECTION CONTINUED.

7–a, 9–a, and 11–a represents "bright coal" or larger anthraxylon components; 8–d and 10–d, "dull coal"; 10–p, petrified inclusions. (×10.)

PLATE XIX.

OPAQUE VERTICAL SECTION CONTINUED.

11–a and 14–a, "bright coal"; 12–d and 15–d, "dull coal"; 13–c, charcoal. (×10.)

PLATE XX.

OPAQUE VERTICAL SECTION CONTINUED.

15–d, 17–d, 19–d, 21–d, and 24–d, "dull coal"; 16–a, 18–a, and 20–a, thin strips of "bright coal;" 22–a, "bright coal," derived from a hollow stem; 23–d, débris in the hollow part of 22–a. (× 10.)

PLATE XXI.

OPAQUE VERTICAL SECTION CONTINUED.

24–d and 26–d, "dull coal," or débris, including a thin strip of anthraxylous coal, 25–a. (× 10.)

PLATE XXII.

OPAQUE CROSS SECTIONS.

A. Opaque polished section of the Royalton coal (× 10) photographed by means of reflected light to show the lamination of the "dull coal," but mainly to show the cross sections of the so-called rodlets. Horizontal cleavage surfaces of layers similar to the layers seen at 3–r are shown in Plate XXXV, *A* and *B*.

B. Opaque polished vertical section (× 10), prepared in a similar way, from another horizon of the Royalton coal, representing its general lamination into thin lenticular laminæ of "bright coal," or anthraxylon shown in black embedded in the attritus in gray. Inclusions of charcoal are shown in the lower part.

PLATE XXIII.

OPAQUE CROSS SECTION.

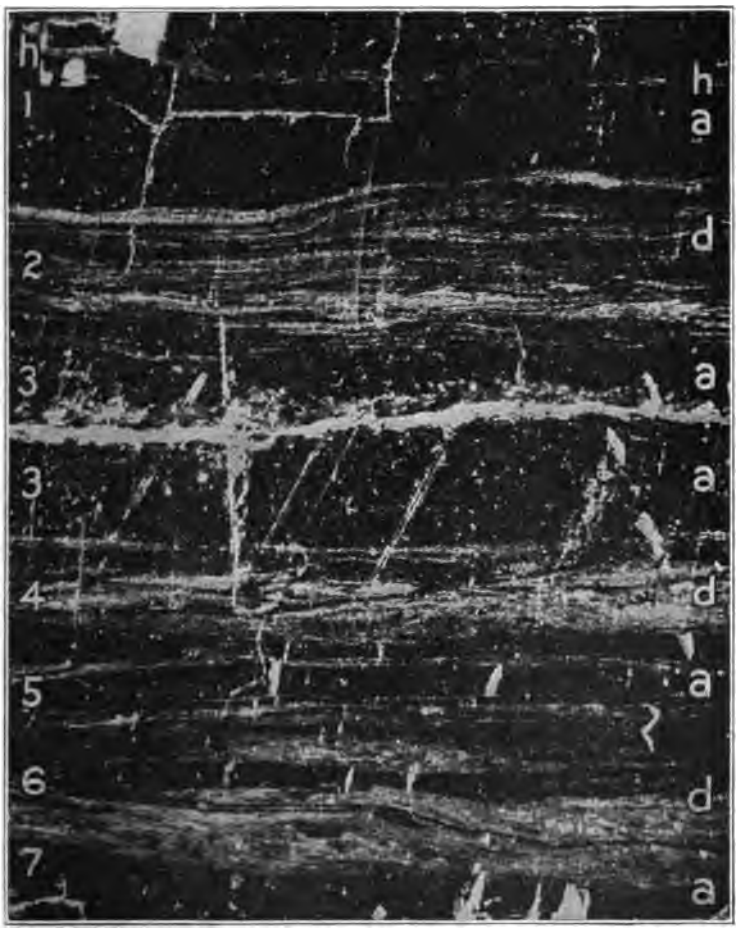
An opaque polished cross section (×10) prepared by means of reflected light, from the coal from Zeigler, Ill., representing mainly a portion of the "dull coal," between the two anthraxylon components 1–a and 5–a. Note the lumping of the attritus and the cross section of rodlets at 2–d.

PLATE XXIV.

OPAQUE CROSS SECTIONS.

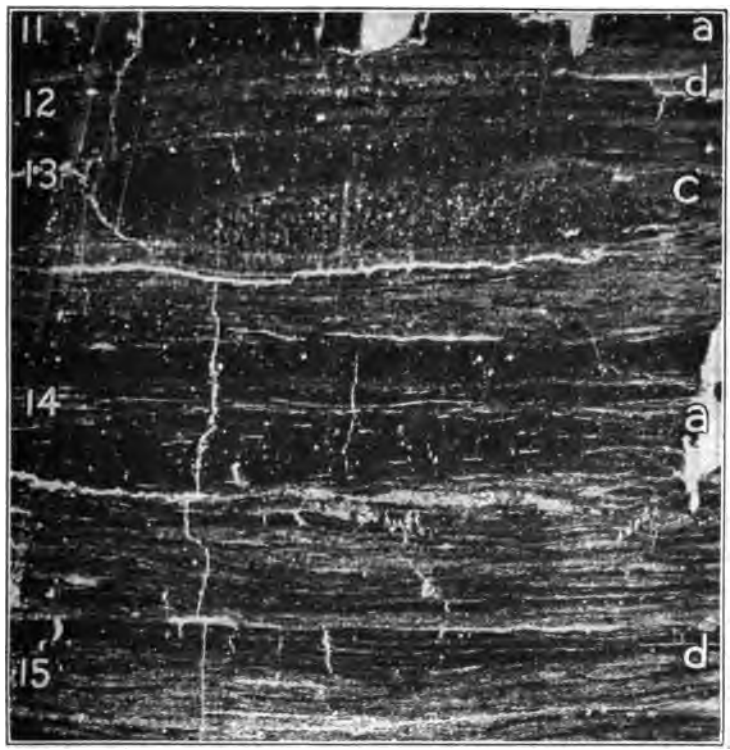
A. An opaque, polished cross section (×10) of the coal from Zeigler, Ill., representing thin laminæ composed of matter derived from the woody parts of plants alternating with matter derived largely from leaves. The dark strips represent anthraxylon, and the light, delicate striations represent leaf cuticles including an attritus largely derived from leaf tissues. Similar laminæ more highly magnified, are shown in Plate XCVIII, *A* and *B*.

B. An opaque, polished cross section from the Sesser coal (×10), showing "dull coal" at 1–d and 3–d and anthraxylon at 2–a and 4–a. Plate CI, *A* (×200), Plate CI, *B*, and Plate CII, *A* (×1,000) are prepared from a cross section of the anthraxylon shown at 2–a in this photograph.

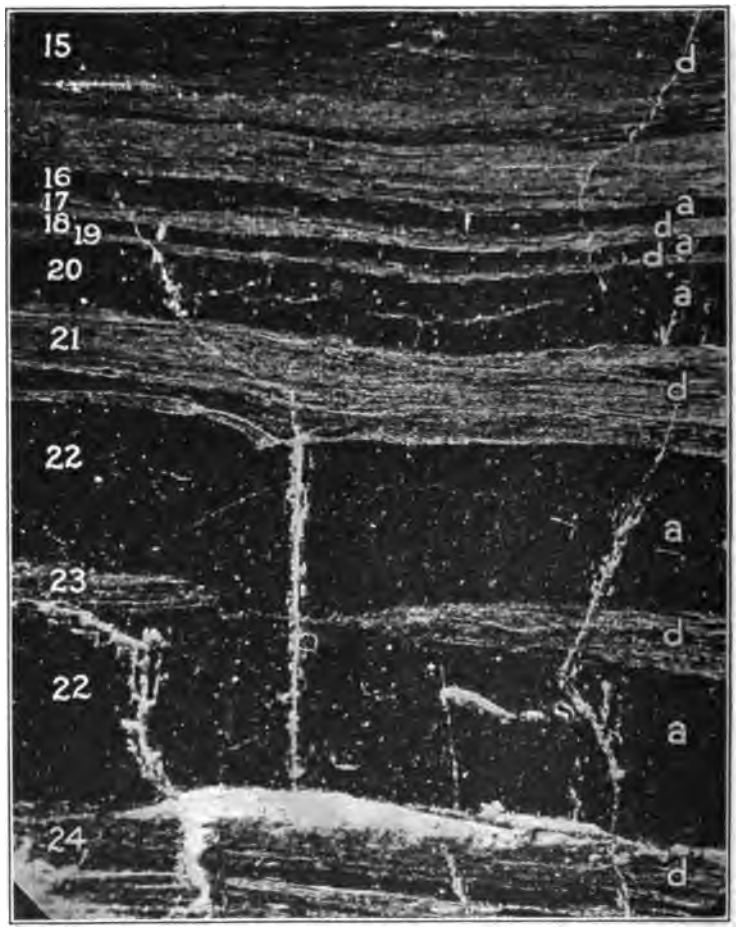


OPAQUE VERTICAL SECTION OF COAL FROM ROYALTON, ILL. (X 10)

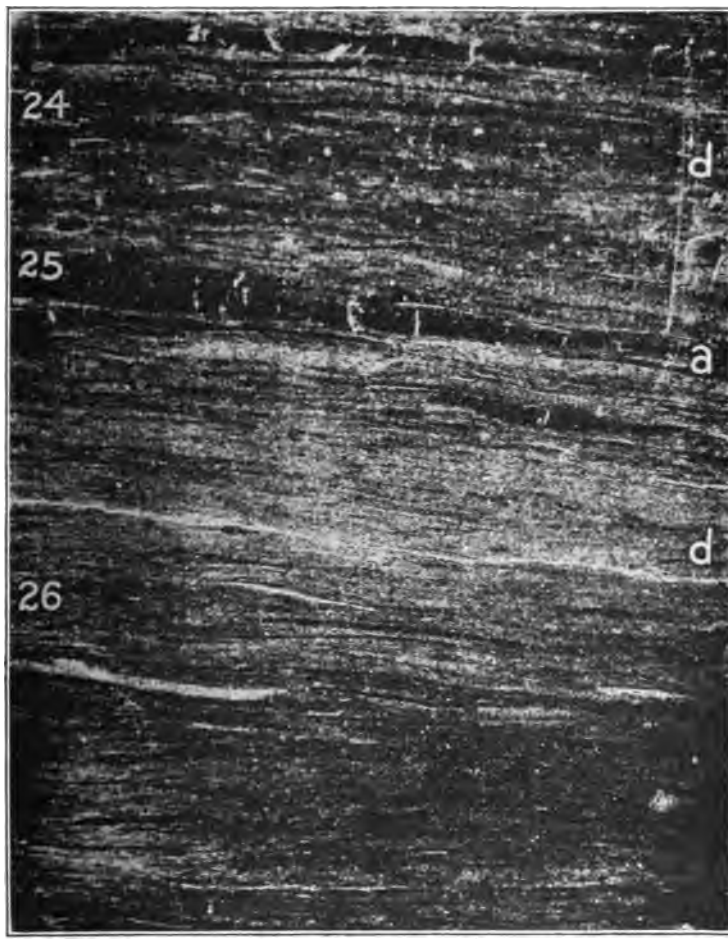
CONTINUATION FROM PLATE XVII. (X 10)



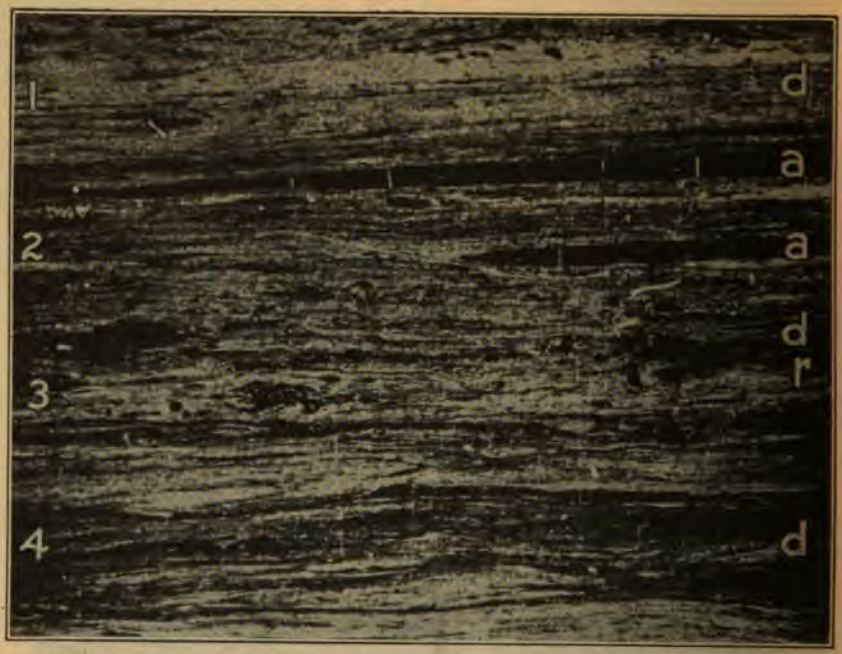
CONTINUATION FROM PLATE XVIII. (X 10)



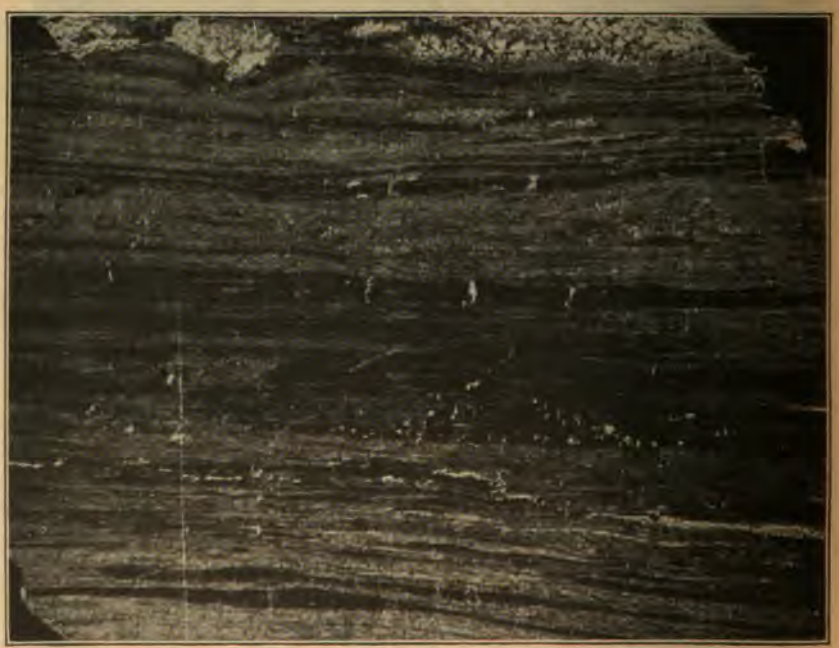
CONTINUATION FROM PLATE XIX. (X 10)



CONTINUATION FROM PLATE XX. (X 10)



A. CROSS SECTION OF RODLETS IN COAL FROM ROYALTON, ILL. (X 10)



B. LAMINATION IN COAL FROM ROYALTON, ILL. (X 10)

OPAQUE CROSS SECTION OF COAL FROM ZEIGLER, ILL. (X 10)

A. OPAQUE CROSS SECTION OF THIN LAMINAE, COAL FROM ZEIGLER, ILL. (X 10)

B. OPAQUE CROSS SECTION OF COAL FROM SESSER, ILL. (X 10)

PLATE XXV.

HORIZONTAL CLEAVAGE SURFACE.

A horizontal cleavage surface of the coal from the Vandalia mine (×2), from the block of coal shown in Plate CXLII, along the level indicated by x–x through a compact part of the coal. On its surface are exposed the anthraxylon components shown as small, thin chips in cross section in Plate CXLIII, *A* and *B;* here shown as small woody patches. Some of these patches contain fine rodlets.

PLATE XXVI.

HORIZONTAL CLEAVAGE SURFACE.

Another horizontal cleavage surface the Vandalia coal (×2), from the block represented in Plate CXLII, from a fracture along the level indicated by y–y showing typical structure of the coal, mainly small anthraxylon chips.

PLATE XXVII.

HORIZONTAL CLEAVAGE SURFACE.

A horizontal cleavage surface through the compact coal of the coal from the Benton mine magnified a little more than natural size, showing the woody patches or anthraxylon components on the broad side. Notice that the whole surface shown is covered with patches showing woody structures.

PLATE XXVIII.

HORIZONTAL CLEAVAGE SURFACE.

A. Horizontal cleavage surface along the level x–y–z, fracture 1, of the block of the coal from the Benton mine shown in Plate XI, *A* and *B*. The sides, x–y, y–z, and z–x correspond to the sides x–y, y–z, and z–x of the block shown in Plate XI, *A* and *B*. On the surface are a number of patches, or anthraxylon components, showing woody structure, and many fine "needles" or "rodlets." embedded in the attritus.

B. Another horizontal cleavage surface along the level t–u–v, fracture 2. in the block of coal represented in Plate XI, *A* and *B*. The sides t–u, u–v, and v–t correspond to the sides t–u, u–v, and v–t of the sides of the block represented in Plate XI, *A* and *B*. This surface shows a larger total structureless area in which a number of woody patches, or anthraxylon chips, are located. At the corner "u" the fracture splits through a thicker anthraxylon chip.

PLATE XXIX.

HORIZONTAL CLEAVAGE SURFACE.

Two horizontal cleavage planes from the Hart-Williams coal. The upper surface shows a number of anthraxylon chips, some containing "needles." The lower surface is largely through the interior of an anthraxylon chip, but also shows several patches with woody structures.

PLATE XXX.

HORIZONTAL CLEAVAGE SURFACE.

A horizontal cleavage surface through compact coal of the Sesser coal of the block shown in Plate X, along the horizon indicated by x–y, magnified a little more than natural size, and showing structures similar to the Hart-Williams coal. Some of the woody patches contain "needles." The irregular dark areas represent fractures through the interior of the anthraxylon chips.

PLATE XXXI.

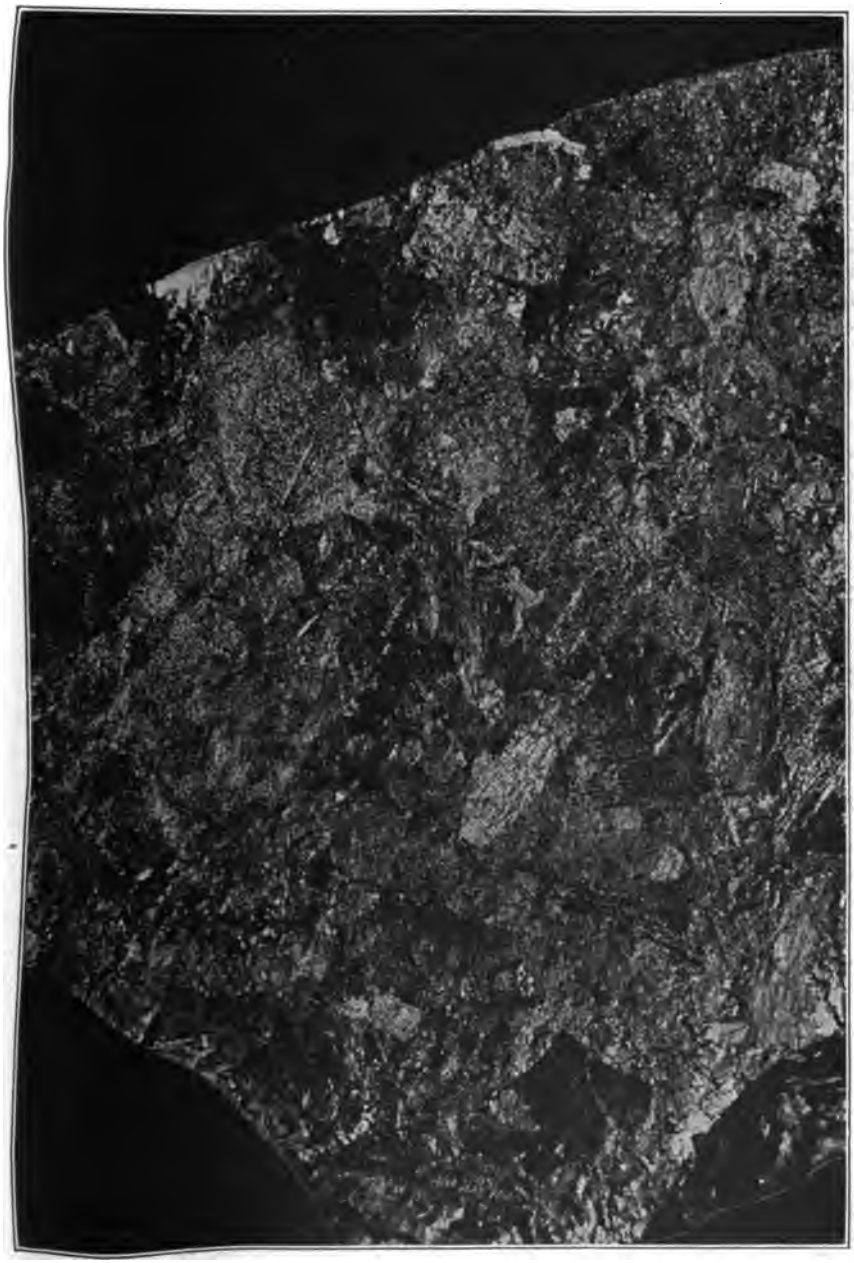
HORIZONTAL CLEAVAGE SURFACE.

A horizontal cleavage surface of the Buxton coal (×5), showing the general structure and appearance.

PLATE XXXII.

HORIZONTAL CLEAVAGE SURFACE.

Part of another horizontal cleavage surface of the Buxton coal (×10), showing the woody fibers, cuticles, and "needles."



HORIZONTAL CLEAVAGE SURFACE OF COAL FROM THE VANDALIA MINE, NEAR TERRE HAUTE, IND. (X 2)

ANOTHER HORIZONTAL CLEAVAGE SURFACE OF COAL FROM THE VANDALIA MINE. (X 2)

HORIZONTAL CLEAVAGE SURFACE OF COAL FROM BENTON, ILL.

A. HORIZONTAL CLEAVAGE SURFACE OF COAL FROM BENTON, ILL., FROM LUMP SHOWN IN PLATE XI.

B. ANOTHER CLEAVAGE SURFACE OF LUMP OF COAL SHOWN IN PLATE XI.

HORIZONTAL CLEAVAGE SURFACES OF COAL FROM THE HART-WILLIAMS MINE.

HORIZONTAL CLEAVAGE SURFACE OF COAL FROM SESSER, ILL.

HORIZONTAL CLEAVAGE SURFACE OF COAL FROM BUXTON, IOWA, SHOWS GENERAL STRUCTURE AND APPEARANCE. (X 5)

HORIZONTAL CLEAVAGE SURFACE OF COAL FROM BUXTON, IOWA, SHOWS WOODY COMPONENTS. (X 10)

PLATE XXXIII.

HORIZONTAL CLEAVAGE SURFACE.

A horizontal cleavage surface of the Buxton coal (×10), containing a large amount of fragmentary cuticles and some woody patches.

PLATE XXXIV.

HORIZONTAL CLEAVAGE SURFACE.

A. An oblique section, slightly enlarged, through the compact coal of the Zeigler coal. The irregular black areas and heavy lines represent the fracture through anthraxylon chips; the grayish areas represent largely the attritus.

B. A horizontal cleavage fracture (×10) through compact coal of the Royalton coal, showing an area with only a few woody patches and a number of "rodlets" or "needles" or their impressions.

PLATE XXXV.

HORIZONTAL CLEAVAGE SURFACE.

A and *B*. Horizontal cleavage surfaces (×10) through layers of the Royalton coal similar to the layer shown at 3–r, Plate XXII, *A*, showing a number of rodlets, bits of coalified woody tissues, parts of stems, petioles, cuticles, and attritus. Similar fractures are found in many coals.

PLATE XXXVI.

COAL FROM THE PITTSBURGH BED.

A. Entire vertical cut of an outcrop, very much reduced, of the Pittsburgh bed, between Hobart and Beacon Streets, west of Whitman Street in Pittsburgh, Pa., showing the general layering of the coal as seen in the seam, which is 11 to 12 feet thick here. The lighter layer toward the top of the seam, at 1–p, represents the clay parting persistently found throughout the seam.

B. A piece of coal, natural size, from the Pittsburgh seam showing the macroscopic appearance, the lamination, and the structure of the Pittsburgh coal. 1–d, 3–d and 5–d represent the so-called "dull coal," 2–a represents a layer of the "bright coal", or anthraxylon; at 4–a is a much thinner strip of "bright coal." The "dull coal" is also composed of thin dull and bright layers alternating with each other. The "bright laminæ," black laminæ in the photograph, are shaped like thin lenses and are embedded in the attritus.

PLATE XXXVII.

OPAQUE VERTICAL SECTION OF THE PITTSBURGH COAL FROM THE OAK MINE.

An opaque cross section of Pittsburgh coal from the first foot of coal below the roof at the Oak mine. (×10.) The gray matter represents the attritus, and the delicate black strips thin anthraxylon chips. Note that some layers are composed of pure attritus. Note also the exines at 4–d, and the carbonaceous inclusion at 5–d. Observe the general distribution of the constituents, the general structure of the thin sheets, and the proportion of attritus to anthraxylon.

PLATE XXXVIII.

CONTINUED FROM PLATE XXXVII.

An opaque cross section of the dull coal the second foot from the roof in the Pittsburgh bed at the Oak mine. (×10.) The coal contains more matter derived from chips of wood, or anthraxylon matter, than that shown in Plate XXXVII.

PLATE XXXIX.

CONTINUED FROM PLATE XXXVIII.

An opaque cross section of the third foot of coal below the roof in the Pittsburgh seam, at the Oak mine (×10), showing the general structure. Notice that there is a larger proportion of anthraxylon matter in the third foot than in the second (Pl. XXXVII) or the first foot of coal (Pl. XXXVIII). Megaspore exines are shown in the region 2–d to 3–d.

PLATE XL.

CONTINUED FROM PLATE XXXIX.

An opaque cross section of the fourth foot of coal from the roof in the Pittsburgh seam at the Oak mine. (×10.) The anthraxylon is here more disintegrated. Note the megaspore-exines, in light gray, particularly, in the region 3–d to 4–d. At 5–d is an inclusion of "mother coal" or carbonaceous matter showing cell structure, many of the cells being filled with quartz.

HORIZONTAL CLEAVAGE SURFACE OF COAL FROM BUXTON, IOWA, SHOWS FINELY DIVIDED WOODY MATTER. (X 10)

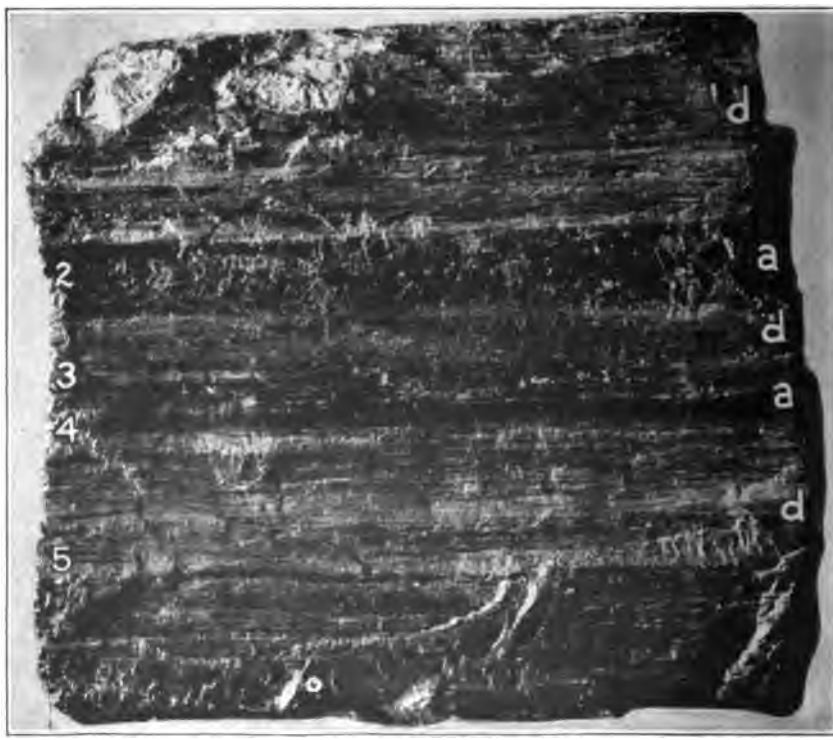
A. HORIZONTAL CLEAVAGE SURFACE OF COAL FROM ZEIGLER, ILL.

B. HORIZONTAL CLEAVAGE SURFACE THROUGH "COMPACT" COAL OF THE COAL FROM ROYALTON, ILL. (X 10)

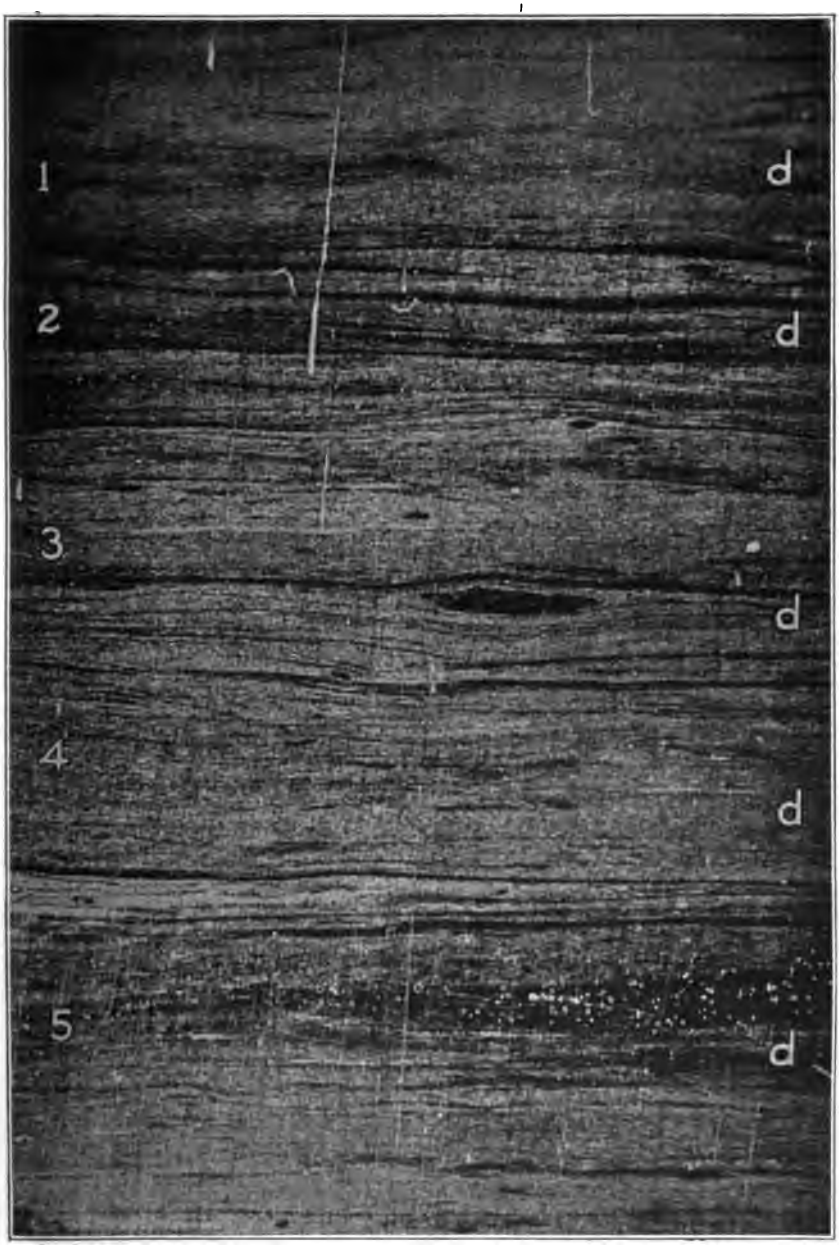
A. HORIZONTAL CLEAVAGE SURFACE OF THE COAL FROM ROYALTON, ILL., SHOWING RODLETS AND WOODY TISSUES. (X 10)

B. HORIZONTAL CLEAVAGE SURFACE OF THE COAL FROM ROYALTON, SIMILAR TO THAT ABOVE. (X 10)

A. WHOLE SECTION OF OUTCROP OF PITTSBURGH COAL, GREATLY REDUCED.



B. A LUMP OF PITTSBURGH COAL.



OPAQUE VERTICAL SECTION OF COAL FROM THE OAK MINE, FIRST FOOT. (X 10)

OPAQUE VERTICAL SECTION OF COAL FROM THE OAK MINE, SECOND FOOT.
(X 10)

OPAQUE VERTICAL SECTION OF COAL FROM THE OAK MINE, THIRD FOOT. (X 10)

OPAQUE VERTICAL SECTION OF COAL FROM THE OAK MINE, FOURTH FOOT.
(X 10)

PLATE XLI.

CONTINUED FROM PLATE XL.

An opaque cross section of the coal from the fifth foot from the roof, or the first foot from the floor, in the Pittsburgh bed at the Oak mine. (×10.) There is a large proportion of anthraxylon. At 2-a are two very thin anthraxylon components.

PLATE XLII.

STRUCTURE OF PITTSBURGH COAL FROM THE EXPERIMENTAL MINE.

An opaque cross section of the coal from the Pittsburgh bed at the Experimental mine, Bruceton, Pa. (×10.) Attritus is shown in gray, anthraxylon in black. The structure and composition is similar to that of the coal from the Oak mine just shown.

PLATE XLIII.

OPAQUE VERTICAL SECTION.

Another opaque cross section of the coal from the Pittsburgh seam at the Experimental mine, Bruceton, Pa. (×10), showing the general structure. Some of the anthraxylon chips are almost thick enough to be recognized macroscopically as "bright coal."

PLATE XLIV.

THIN VERTICAL SECTIONS.

A. A thin cross section of the coal from the first foot from the roof of the Oak mine (×10), photographed by means of transmitted light, showing the proportion of the anthraxylon to the attritus and the appearance of the anthraxylon at low magnification. The anthraxylon is shown as the gray bands, and the attritus in the black bands. The anthraxylon looks ragged. In the upper part is seen a carbonaceous inclusion, and in the central part smaller carbonaceous resinous nodules.

B. The lower half of *A* (×20), showing the same components in better detail. The photographs at low magnifications by transmitted light mainly serve as intermediates between the macroscopic appearance and that at high magnifications.

NOTE.—The constituents shown in black in the photographs of thin sections are not always black or opaque in the sections, but most of them are transparent, or at best translucent and are dark red. The natural humic matter and the anthraxylon components range from orange to light red and the sporexines from light to golden yellow, transmitting light readily.

PLATE XLV.

CONTINUED FROM PLATE XLIV.

A. A thin section from the second foot of coal from the roof of the Oak mine (×10), showing an anthraxylous layer in the upper half and one of relatively pure attritus in the lower half. The delicate layering of the anthraxylon components is clearly shown, with interlayers of attritus. The lighter mottling in the lower half largely represents spore matter.

B. A thin cross section of the coal from the Oak mine from the same horizon as *A* (×20), showing the structure and nature of the components more clearly, also a considerable amount of carbonaceous matter in several places.

PLATE XLVI.

CONTINUED FROM PLATE XLV.

A. A thin section of coal from the third foot from the roof of the Oak mine (×10), showing a larger proportion of anthraxylon matter which is more compact than in coal from the first and second foot. The megaspore-exines and the microspore-exines are everywhere in the attritus between the anthraxylon strips.

B. A section similar to *A.* (×20.) Laminæ of carbonaceous attritus are seen in the upper part and a resinous anthraxylon strip in the central part. The lower part shows a layer of dull coal rich in attritus, a large proportion of which is carbonaceous matter.

PLATE XLVII.

CONTINUED FROM PLATE XLVI.

A. A thin cross section from the fourth foot of the Oak mine coal (×10), showing that the coal is more anthraxylous than at the third foot. The anthraxylon is compactly layered.

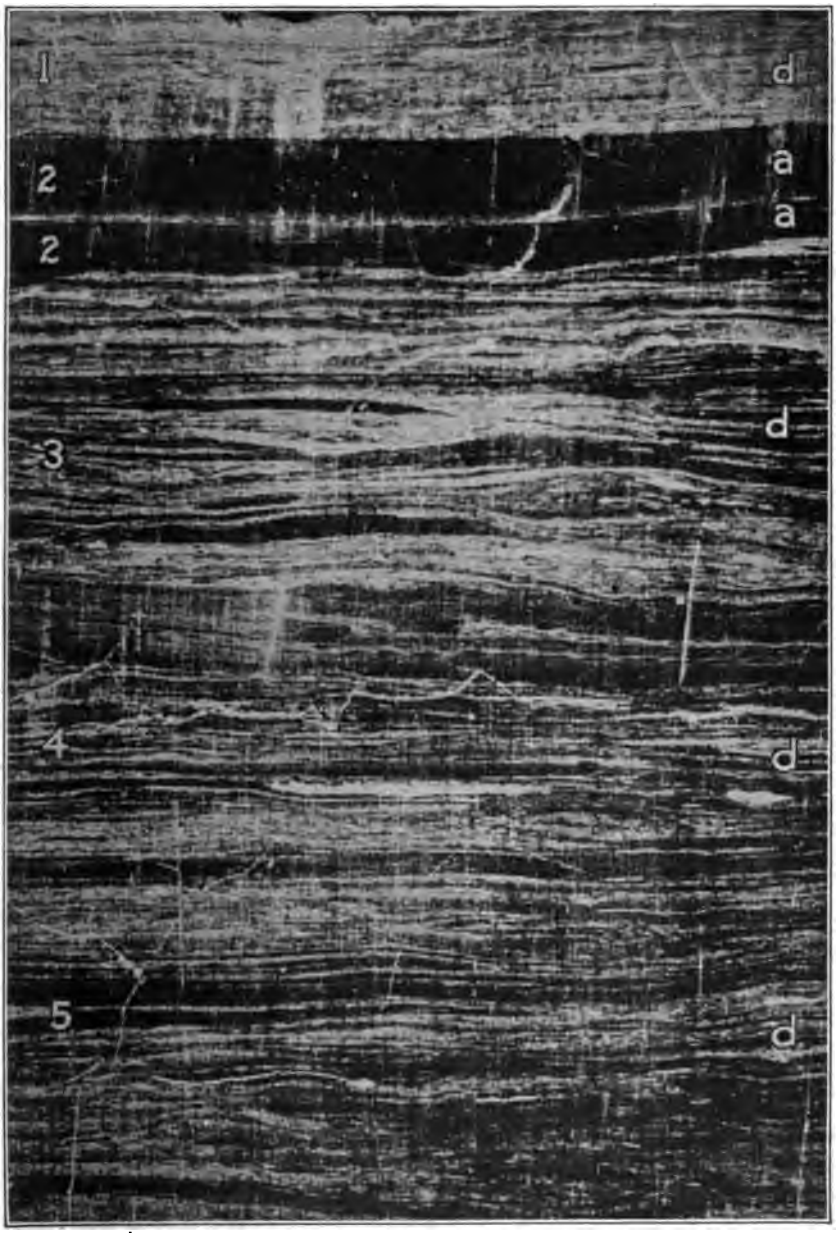
B. A thin cross section from the same horizon as *A* (×20), showing the nature of the coal more clearly. The attritus wedged between the anthraxylous matter is similar to that shown in the coal from the other levels.

PLATE XLVIII.

THIN VERTICAL SECTIONS.

A. A thin section of coal from the fifth level from the top or the first foot from the floor at the Oak mine, prepared by transmitted light. (×20.) The coal from this level is not as compact as that from the third and the fourth foot levels but is very woody. The larger and the smaller megaspores are seen in the attritus. The large exines in the lower part of the photograph measure approximately 1,250 microns or 1½ mm. across the disk.

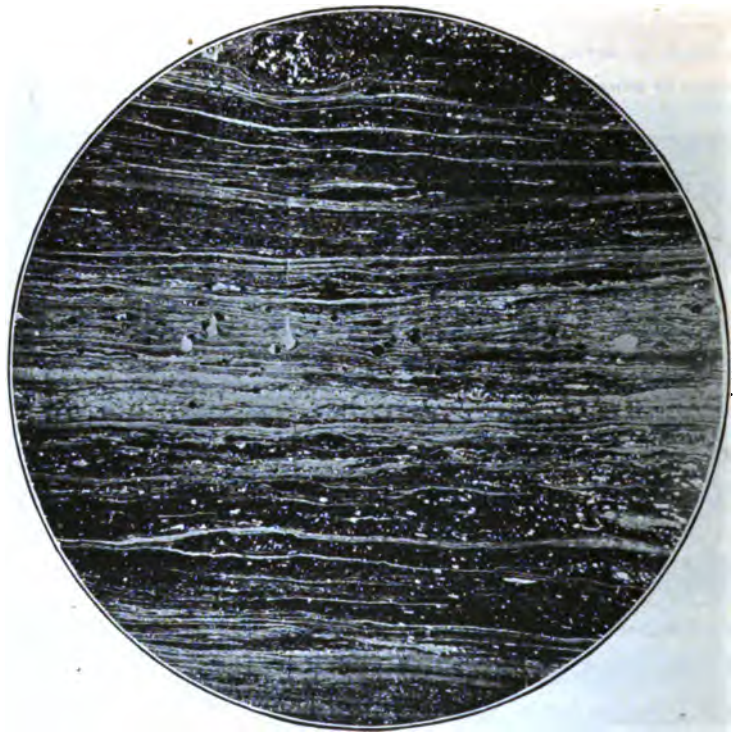
B. Part of the same section as shown in Plate XLIV, *A* (×200), showing two anthraxylon strips, 1–a and 3–a, and two sheets of attritus, 2–d and 4–d, layered between the anthraxylon strips, in greater detail. The cell structure and also characteristic resinous inclusions are shown in the anthraxylon strips. Spore-exines and humic matter are seen embedded in the attritus in a carbonaceous groundmass, the detail of which is not shown.



OPAQUE VERTICAL SECTION OF COAL FROM THE OAK MINE, FIFTH FOOT.
(X 10)

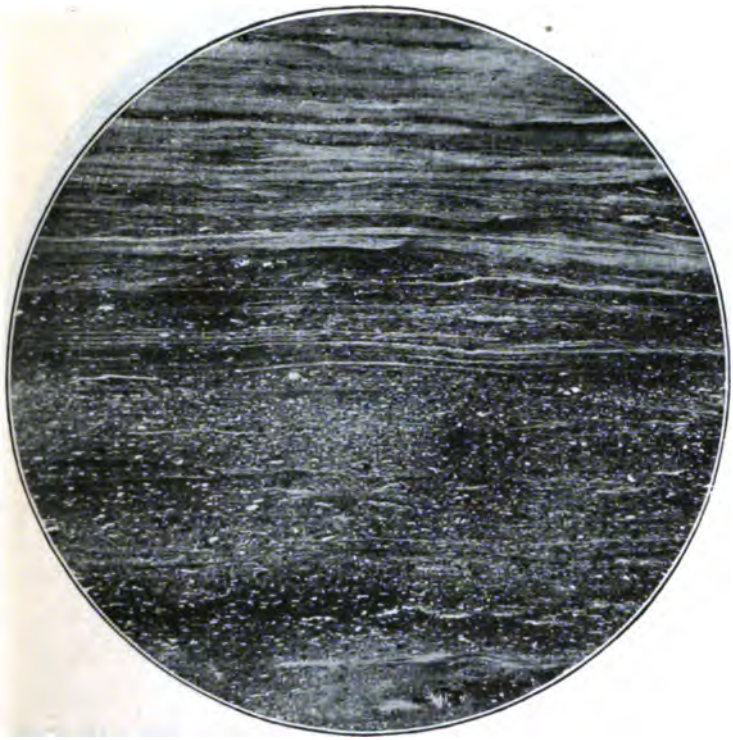
OPAQUE VERTICAL SECTION OF COAL FROM THE EXPERIMENTAL MINE.
(X 10)

ANOTHER OPAQUE VERTICAL SECTION OF COAL FROM THE EXPERIMENTAL MINE. (X 10)



A. THIN VERTICAL SECTION OF COAL (X 10) FROM THE OAK MINE, FIRST FOOT.

B. THIN VERTICAL SECTION OF COAL (X 20) FROM THE OAK MINE, FIRST FOOT.

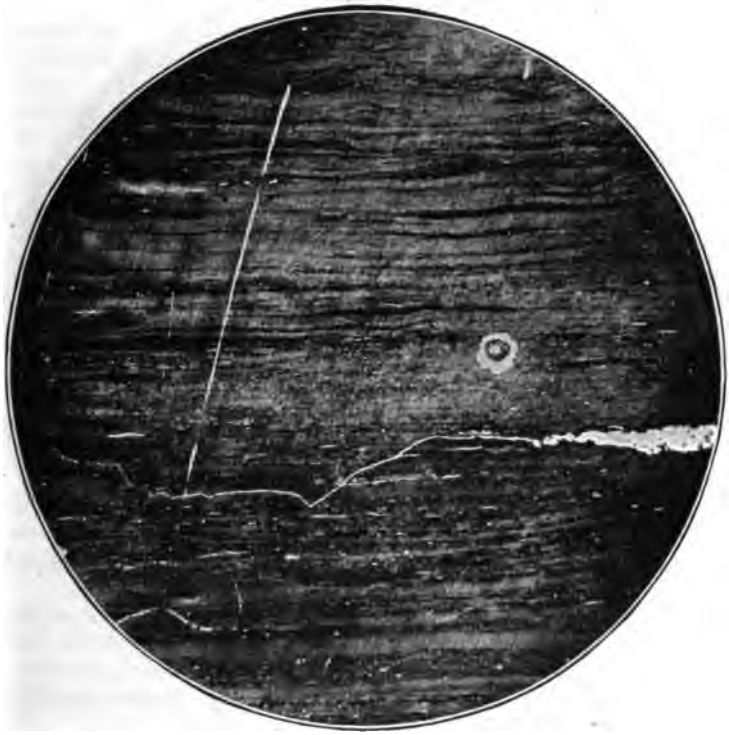


A. THIN VERTICAL SECTION OF COAL (X 10) FROM THE OAK MINE, SECOND FOOT.

B. THIN VERTICAL SECTION OF COAL (X 20) FROM THE OAK MINE, SECOND FOOT.

A. THIN VERTICAL SECTION OF COAL (X 10) FROM THE OAK MINE, THIRD FOOT.

B. THIN VERTICAL SECTION OF COAL (X 20) FROM THE OAK MINE, THIRD FOOT.



A. THIN VERTICAL SECTION OF COAL (X 10) FROM THE OAK MINE, FOURTH FOOT.

B. THIN VERTICAL SECTION OF COAL (X 20) FROM THE OAK MINE, FOURTH FOOT.

A. THIN VERTICAL SECTION OF COAL (X 20) FROM THE OAK MINE, FIFTH FOOT.

B. AREA FROM PLATE XLIV, *A*. (X 200)

PLATE XLIX.

THIN VERTICAL SECTIONS.

A. Part of the section shown in Plate XLIV, *A.* (×200.) At 1–r is a strip of resinous anthraxylon resting on a less resinous part, 2–a. At 3–a is anthraxylon, including resinous matter, in which the original cell structure is still recognizable; similar structures are found at 6–a; at 5–d is a sheet of attritus rich in carbonaceous matter, including a few resinous particles, some humic and some spore matter.

B. A layer of dull coal from the same section shown in *A* (×200), composed of humic, carbonaceous, earthy, and spore matter, and a considerable number of large resinous particles, including the thin anthraxylon strips, 2–a, 4–a, and 5–a, and a somewhat thicker strip with resinous inclusions, 6–a and 7–a. The original cell structure of the anthraxylon strips is still recognizable. The attritus at 3–d is rich in carbonaceous matter.

PLATE L.

THIN VERTICAL SECTIONS.

A. A thin cross section of coal, in the second foot from the roof of the Oak mine (×200), representing a layer of attritus; largely composed of humic matter, some spore matter, some resinous matter, a considerable number of large carbonaceous particles and considerable finely divided carbonaceous matter.

B. Another section from the second-foot level of the Oak mine coal (×200), representing attritus in which are embedded strips of anthraxylon, 3–a, 5–a, and 7–a, and many megaspores, these being very numerous at 1–sp. The width of the megaspores is approximately 75 to 100 microns, or about one-tenth of a millimeter.

PLATE LI.

THIN VERTICAL SECTIONS.

A. A cross section of coal from the second foot from the roof of the Oak mine (×200), showing a layer of attritus mainly composed of spore-exines embedded in a mass of humic and carbonaceous matter, not well differentiated in this photograph.

B. A part of the section included in *A* (×1,000), showing the constituents in detail. The spore-exines are shown here in cross section as irregular crenulated areas. The matrix between the spore-exines is seen to consist of humic and carbonaceous matter. A few resinous particles are present. The humic matter is gray, and the carbonaceous black. Note the minute size of the area represented in this photograph, less than 0.1 mm., or about one two-hundred-and-fortieth inch.

PLATE LII.

THIN VERTICAL SECTIONS.

A. A cross section prepared from the second foot of coal of the Oak mine (×200), showing an anthraxylous layer with some attritus included at 2–d, 4–d, and 7–d. Notice the row of cells below 4–d, the remains of spiral vessels at 6–a, and a cuticle at 5–c.

B. Another cross section from the same level as *A*, showing a large number of thin strips of anthraxylon embedded in an attritus rich in carbonaceous matter, much of which consists of large particles (×200).

PLATE LIII.

THIN VERTICAL SECTIONS.

A. Area from Plate XLIV, *A* (×200), showing a layer of attritus including thin strips of anthraxylon, 1–a and 3–a, and a number of carbonaceous particles. The attritus is composed of spore-exines, humic matter, and much carbonaceous matter. The oval area in 2–d represents a lump of spore-exines intimately united.

B. From an area included in Plate XLIV, *A* (×1000), showing the attritus in detail. The exines in cross section appear crenulated. Note the megaspore in the upper part.

PLATE LIV.

THIN VERTICAL SECTIONS.

A. A thin cross section from the second foot of coal from the Oak mine (×200), containing much granular humic matter and thin anthraxylon strips. The proportion of the spore matter, the carbonaceous matter, and the humic matter is shown.

B. A thin cross section from the second foot of coal from the Oak mine (×200), showing the nature and structure of the anthraxylon chips and the distribution of carbonaceous matter and spore-exines. The cell structure in the anthraxylon is largely, although not altogether, effaced.

PLATE LV.

THIN VERTICAL SECTIONS.

A. A thin cross section (×200) from the third foot from the roof of the Oak mine, representing an anthraxylous layer. The cell remains at 2–a are clearly shown, but at 3–a they are recognizable only as thin striations.

B. A thin section of the coal (×200) from the third foot from the roof of the Oak mine, representing thin anthraxylon chips, 1–a and 3–a, embedded in the attritus. The attritus is rich in carbonaceous matter at 2–d. The cell structure in the anthraxylon is everywhere clearly seen.

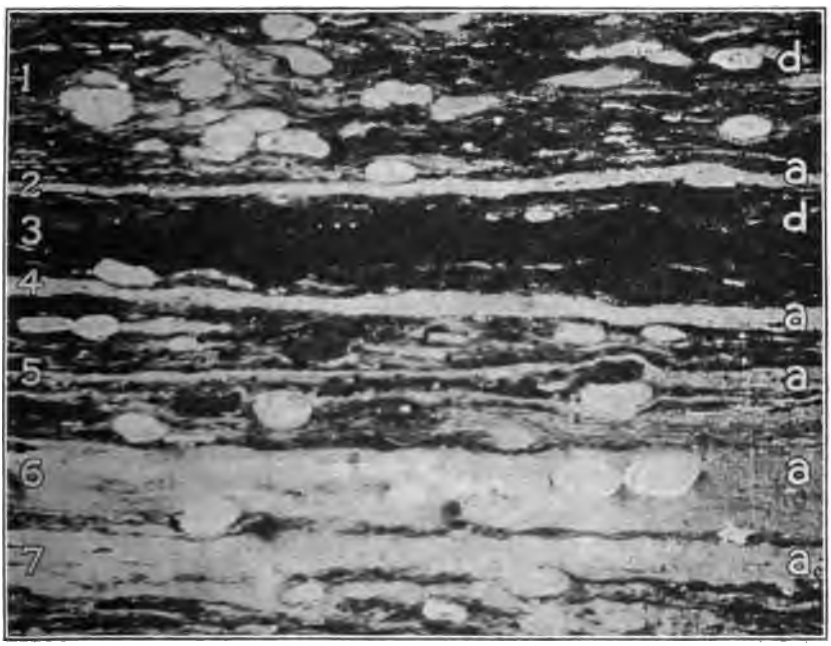
PLATE LVI.

THIN VERTICAL SECTIONS.

A. A thin cross section of coal in the fourth foot from the top, at the Oak mine (×200), showing a peculiar type of tissue very common at this level. At 1–d is shown a strip of granular resinous matter.

B. A thin cross section in the fourth foot of coal from the roof, at the Oak mine (×200), showing at 1–ad a layer of comminuted anthraxylon, at 2–a the same kind of tissue as shown in Plate LVI, *A*, and at 3–a and 4–a compact anthraxylon including some resinous particles. Only a few spore-exines are seen in the attritus.

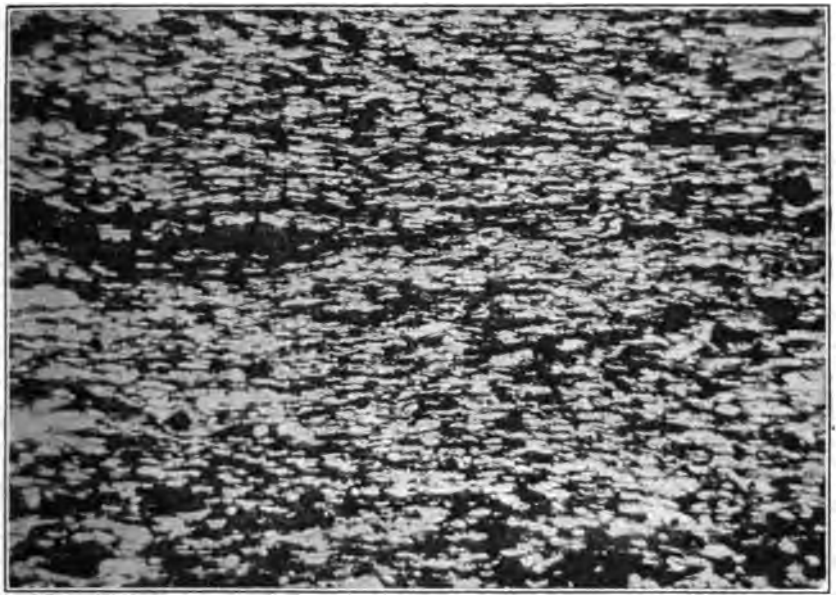
A. PART OF SECTION SHOWN IN PLATE XLIV, *A*. (X 200)



B. LAYER OF DULL COAL FROM THE SAME SECTION SHOWN IN PLATE XLIV, *A*. (X 200)

A. THIN VERTICAL SECTION OF COAL (X 200) FROM THE OAK MINE, SECOND FOOT.

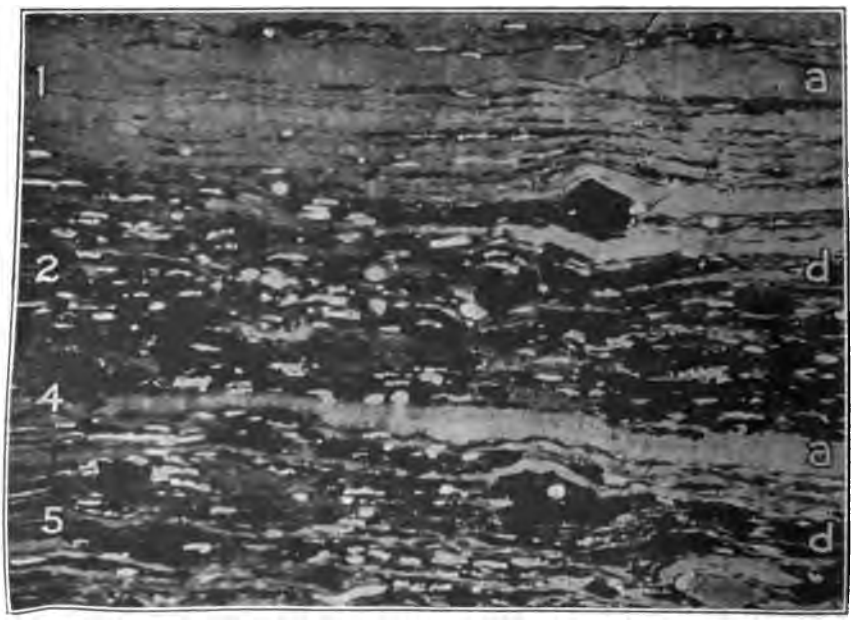
B. ANOTHER THIN VERTICAL SECTION OF SAME COAL AS ABOVE. (X 200)



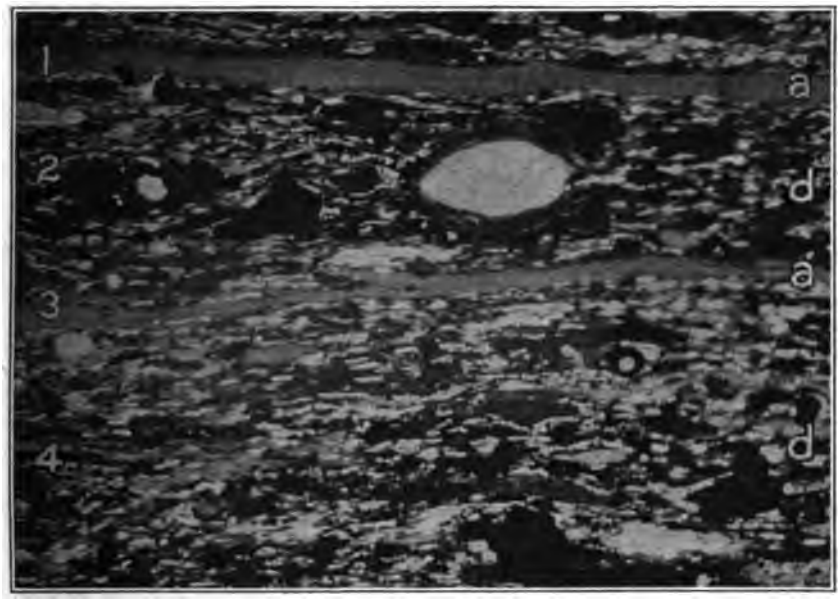
A. THIN VERTICAL SECTION OF COAL (X 200) FROM THE OAK MINE, SECOND FOOT.

B. PART OF SECTION SHOWN ABOVE. (X 1000)

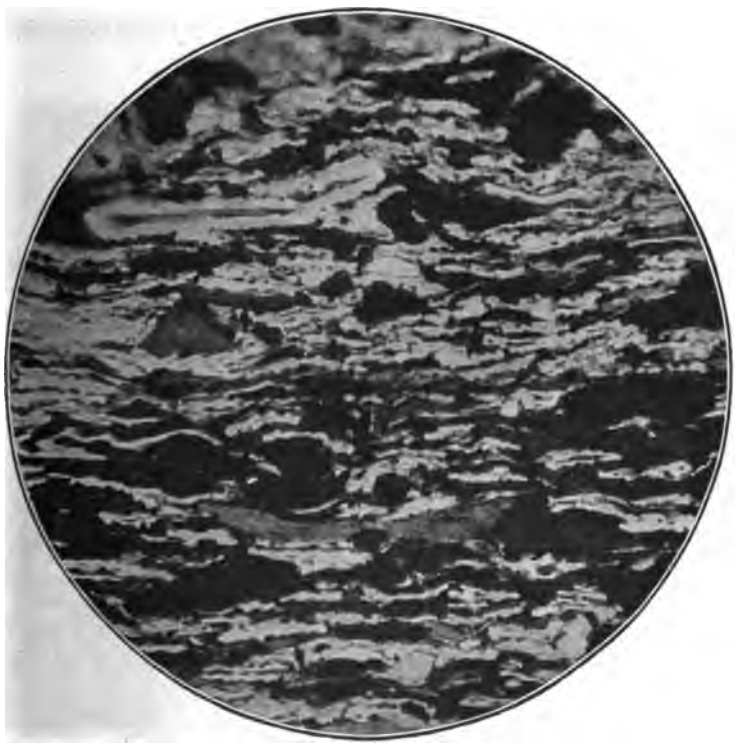
A. THIN VERTICAL SECTION OF COAL (X 200) FROM THE OAK MINE, SECOND FOOT.



B. ANOTHER CROSS SECTION FROM SAME COAL AS ABOVE. (X 200)

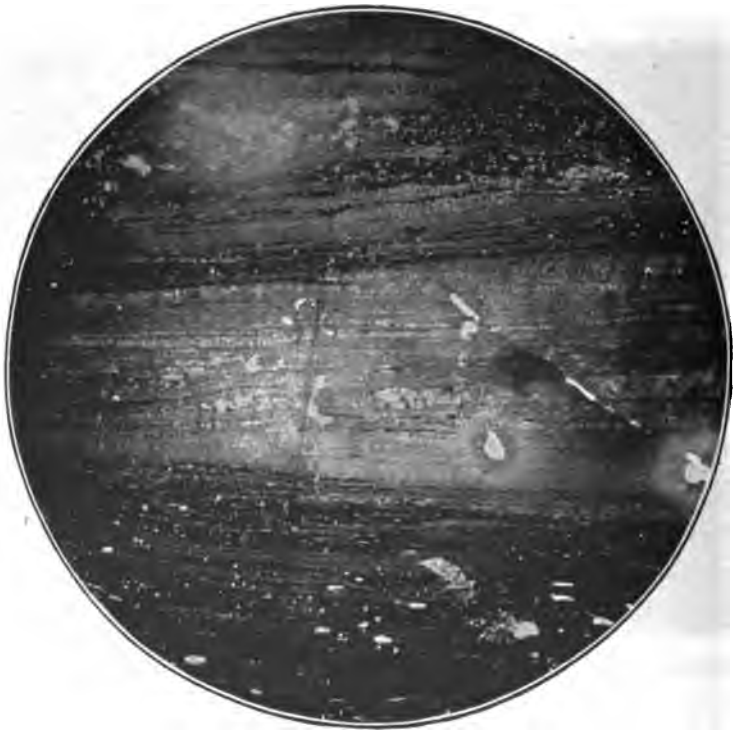


A. AREA FROM PLATE XLIV, *A*. (X 200)

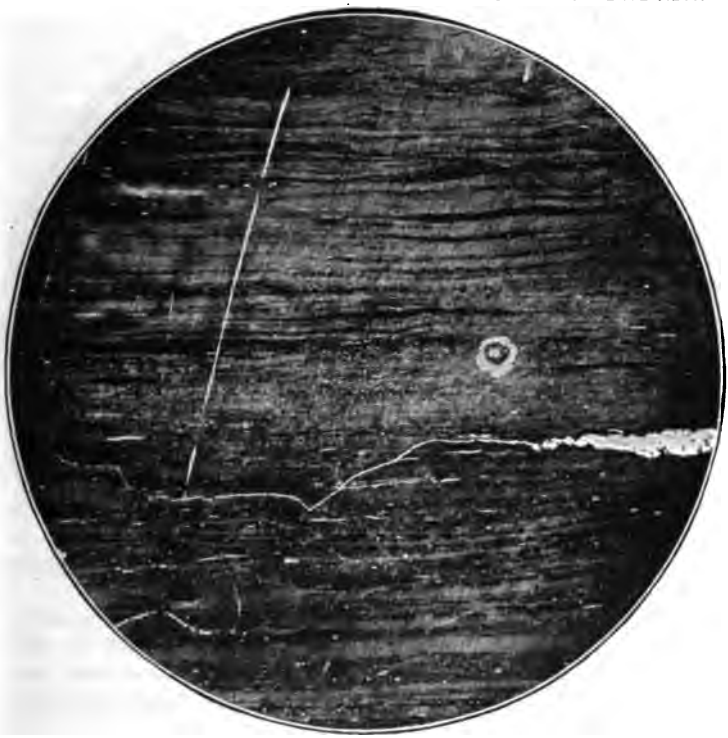


B. AREA FROM PLATE XLIV, *A*. (X 1000)

A. THIN VERTICAL SECTION OF COAL (X 10) FROM THE OAK MINE, THIRD FOOT.



B. THIN VERTICAL SECTION OF COAL (X 20) FROM THE OAK MINE, THIRD FOOT.



A. THIN VERTICAL SECTION OF COAL (X 10) FROM THE OAK MINE, FOURTH FOOT.

B. THIN VERTICAL SECTION OF COAL (X 20) FROM THE OAK MINE, FOURTH FOOT.

A. THIN VERTICAL SECTION OF COAL (X 20) FROM THE OAK MINE, FIFTH FOOT.

B. AREA FROM PLATE XLIV, *A*. (X 200)

PLATE XLIX.

THIN VERTICAL SECTIONS.

A. Part of the section shown in Plate XLIV, *A.* (×200.) At 1–r is a strip of resinous anthraxylon resting on a less resinous part, 2–a. At 3–a is anthraxylon, including resinous matter, in which the original cell structure is still recognizable; similar structures are found at 6–a; at 5–d is a sheet of attritus rich in carbonaceous matter, including a few resinous particles, some humic and some spore matter.

B. A layer of dull coal from the same section shown in *A* (×200), composed of humic, carbonaceous, earthy, and spore matter, and a considerable number of large resinous particles, including the thin anthraxylon strips, 2–a, 4–a, and 5–a, and a somewhat thicker strip with resinous inclusions, 6–a and 7–a. The original cell structure of the anthraxylon strips is still recognizable. The attritus at 3–d is rich in carbonaceous matter.

PLATE L.

THIN VERTICAL SECTIONS.

A. A thin cross section of coal, in the second foot from the roof of the Oak mine (×200), representing a layer of attritus; largely composed of humic matter, some spore matter, some resinous matter, a considerable number of large carbonaceous particles and considerable finely divided carbonaceous matter.

B. Another section from the second-foot level of the Oak mine coal (×200), representing attritus in which are embedded strips of anthraxylon, 3–a, 5–a, and 7–a, and many megaspores, these being very numerous at 1–sp. The width of the megaspores is approximately 75 to 100 microns, or about one-tenth of a millimeter.

PLATE LI.

THIN VERTICAL SECTIONS.

A. A cross section of coal from the second foot from the roof of the Oak mine (×200), showing a layer of attritus mainly composed of spore-exines embedded in a mass of humic and carbonaceous matter, not well differentiated in this photograph.

B. A part of the section included in *A* (×1,000), showing the constituents in detail. The spore-exines are shown here in cross section as irregular crenulated areas. The matrix between the spore-exines is seen to consist of humic and carbonaceous matter. A few resinous particles are present. The humic matter is gray, and the carbonaceous black. Note the minute size of the area represented in this photograph, less than 0.1 mm., or about one two-hundred-and-fortieth inch.

PLATE LII.

THIN VERTICAL SECTIONS.

A. A cross section prepared from the second foot of coal of the Oak mine (×200), showing an anthraxylous layer with some attritus included at 2–d, 4–d, and 7–d. Notice the row of cells below 4–d, the remains of spiral vessels at 6–a, and a cuticle at 5–c.

B. Another cross section from the same level as *A*, showing a large number of thin strips of anthraxylon embedded in an attritus rich in carbonaceous matter, much of which consists of large particles (×200).

PLATE LXI.

THIN HORIZONTAL SECTIONS.

A. A thin horizontal section (×150) of the first foot of coal from the Oak mine, showing the general appearance of the attritus in a horizontal section. The small circular to slightly oval areas are the spore-exines seen on their broad side, the irregular black areas are more highly carbonized matter or bits of charcoal, and the irregular gray areas are humic matter.

B. A more highly magnified portion of *A* (×1,000), showing the constituents in detail. The sculpturing of the spore-exines, which are gray, circular, and oval areas, is clearly seen. Note the carbonized and more opaque matter and its distribution in the humic matter.

PLATE LXII.

THIN HORIZONTAL SECTIONS.

A. A thin horizontal section from the second foot of coal from the Oak mine (×150), showing the general character of the coal in horizontal section. The larger part of the constituents is attritus; in the lower right-hand part is a horizontal section of an anthraxylon chip in which the cell structure is clear. The different constituents composing the attritus, such as spore-exines, humic matter, and carbonaceous matter, are distinguishable.

B. An area included in A (×1,000), showing the constituents in detail. The oval bodies are the pollen-exines abundant in this coal. A few spore-exines are shown indistinctly; the carbonaceous matter is represented by definite particles greatly varying in size; the humic matter is in gray.

PLATE LXIII.

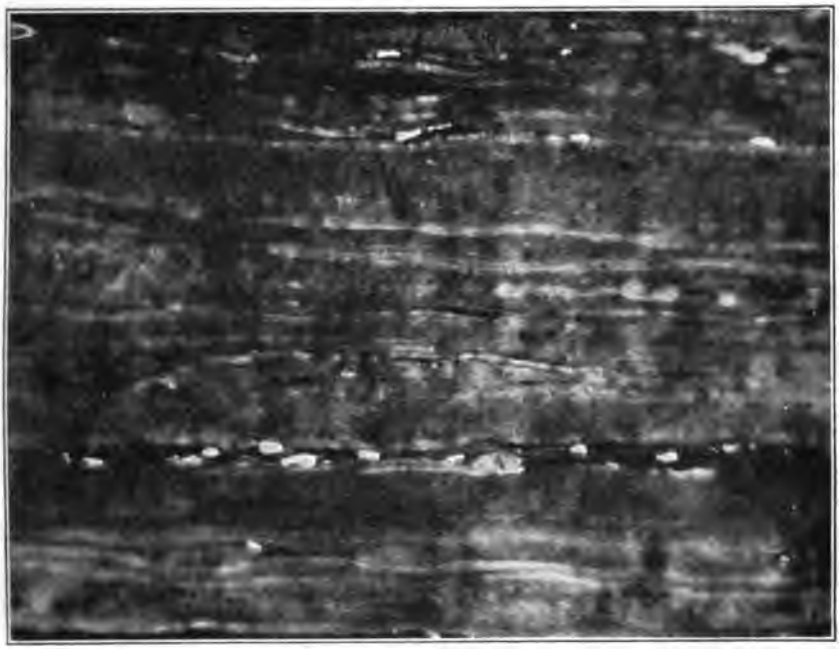
THIN VERTICAL SECTION.

Thin cross section of the Pittsburgh coal from the Experimental mine (×200), continued in Plates LXIV, LXV, and LXVI. The anthraxylon strips at 2–a, 3–a, 5–a, 7–a, and 9–a are distinctly separated from one another by the layers of attritus, 1–d, 4–d, 6–d, 8–d, and 10–d. The attritus is composed largely of humic matter in the form of particles or granules of greatly varying sizes; spore-exines are relatively few, and the proportion of carbonaceous matter is small.

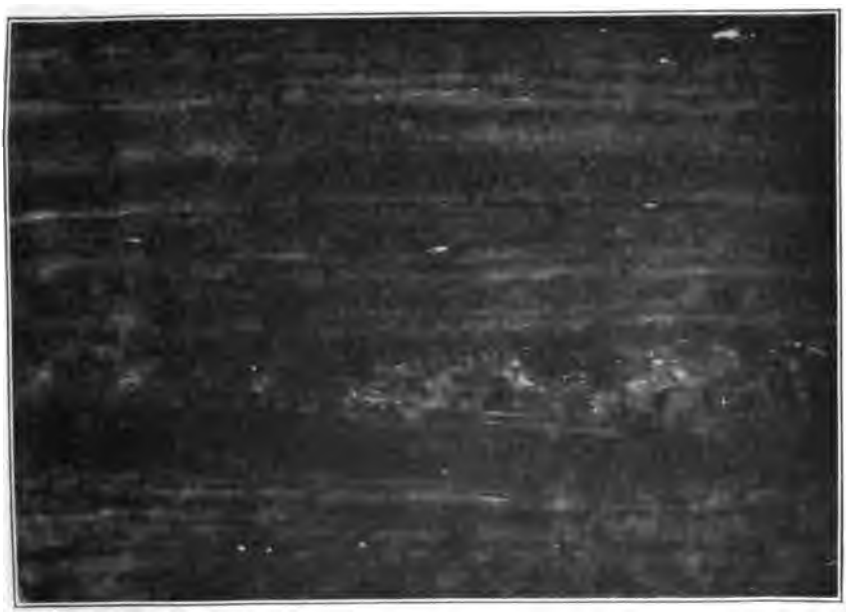
PLATE LXIV.

CONTINUED FROM PLATE LXIII.

The anthraxylon strips, of which there are a number, are not definitely separated by attritus here, but are packed rather closely. The cell structure is distinguishable everywhere.



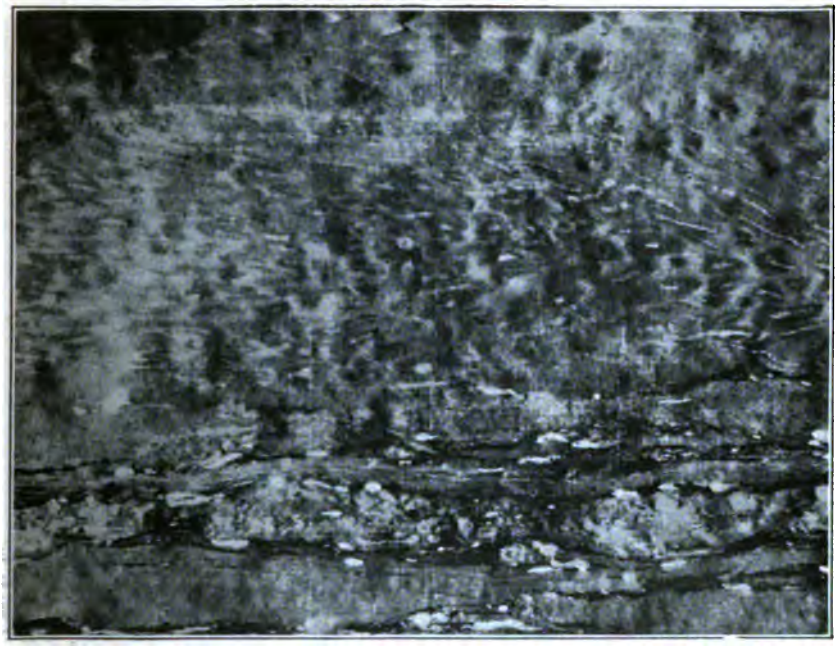
A. A THIN SECTION OF THE SAME COAL SHOWN IN PLATE LVI, SHOWING CELL STRUCTURE OF ANTHRAXYLON STRIPS. (X 200)



B. A THIN SECTION OF THE SAME COAL SHOWN IN PLATE LVI, SHOWING CLOSELY PACKED ANTHRAXYLON STRIPS. (X 200)

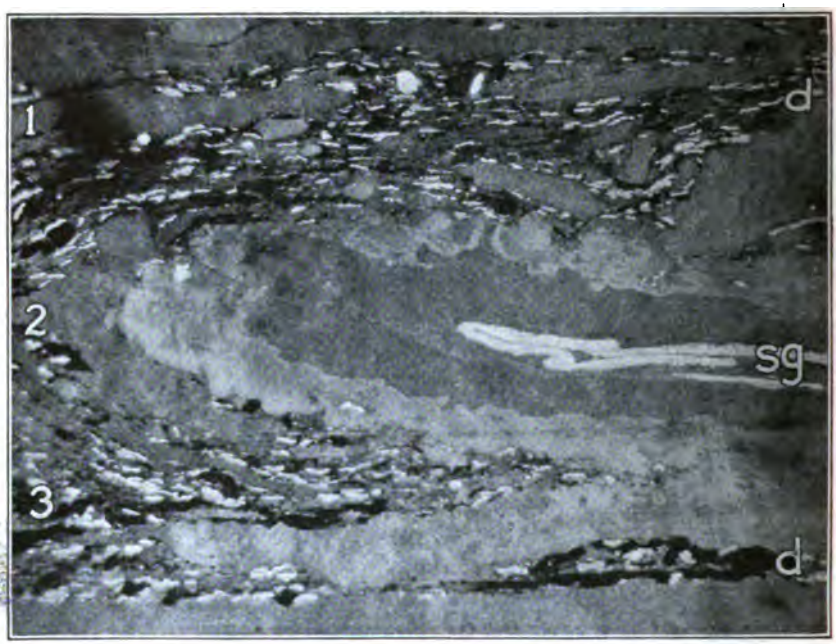
A. THIN VERTICAL SECTION OF COAL FROM THE OAK MINE, FIFTH FOOT. (X 200)

B. ANOTHER SECTION FROM THE FIFTH FOOT OF COAL, OAK MINE. (X 200).

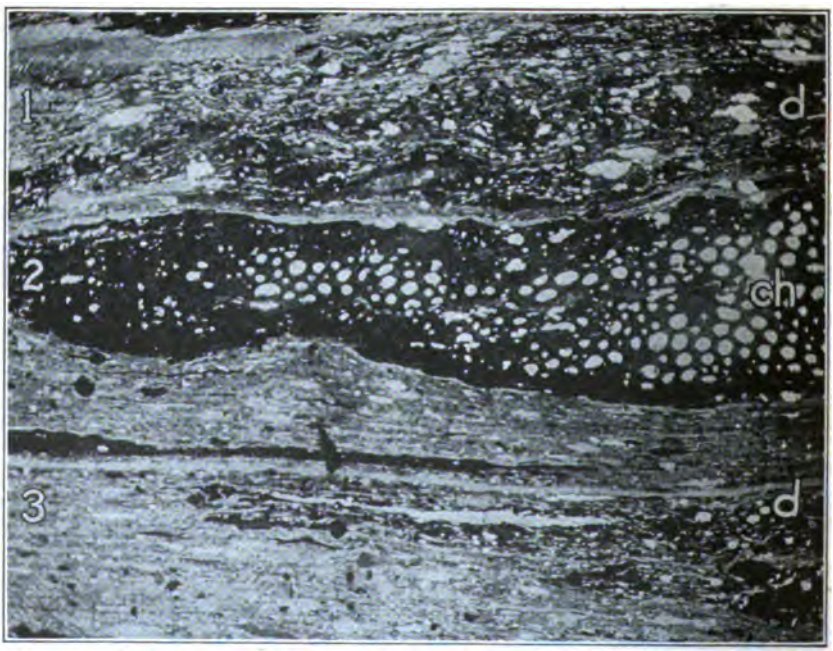


A. A THIN SECTION FROM THE SAME FOOT OF COAL AS THAT SHOWN IN PLATE LVIII. (X 200)

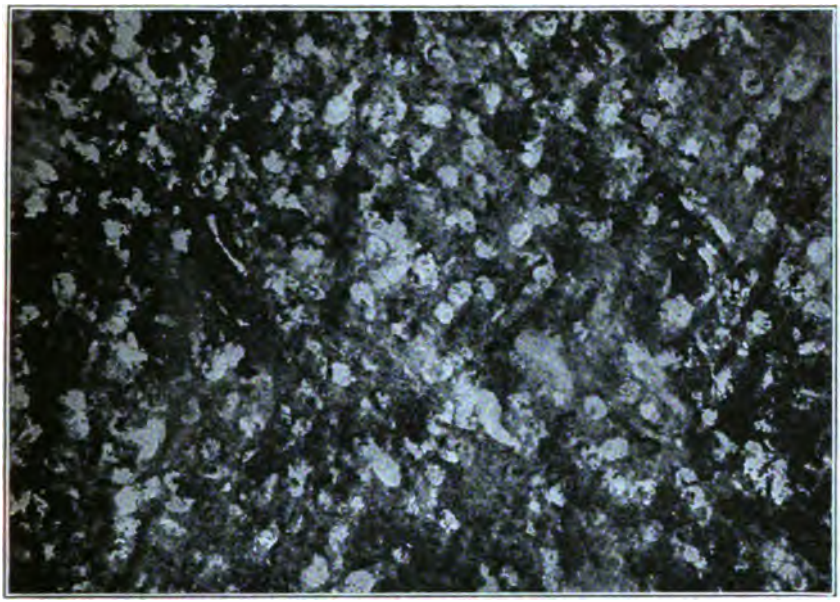
B. THIN SECTION OF ANTHRAXYLON WITH RESINOUS INCLUSIONS. (X 200)



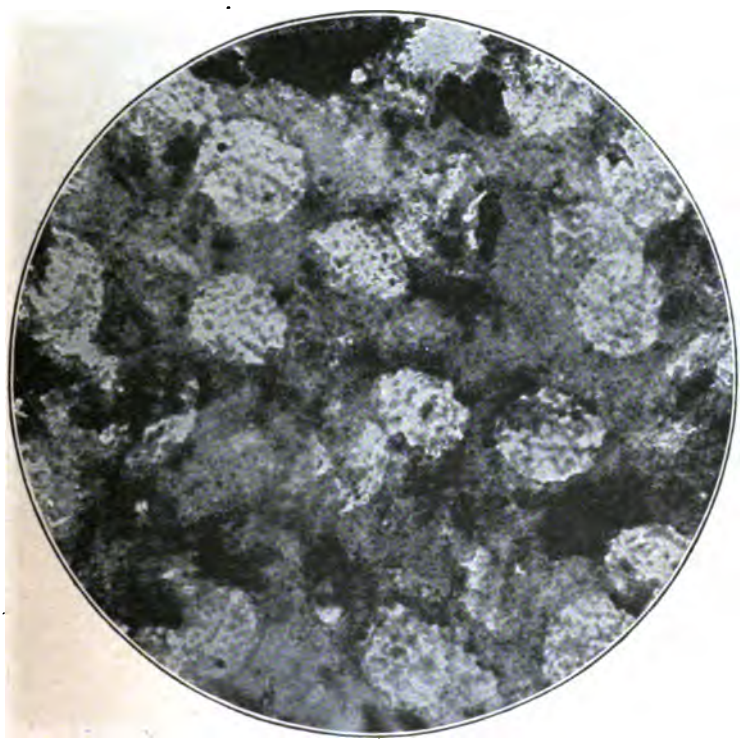
A. MEGASPORANGIUM IN COAL FROM THE OAK MINE. (X 200)



B. CHARCOAL IN COAL FROM THE OAK MINE. (X 200)

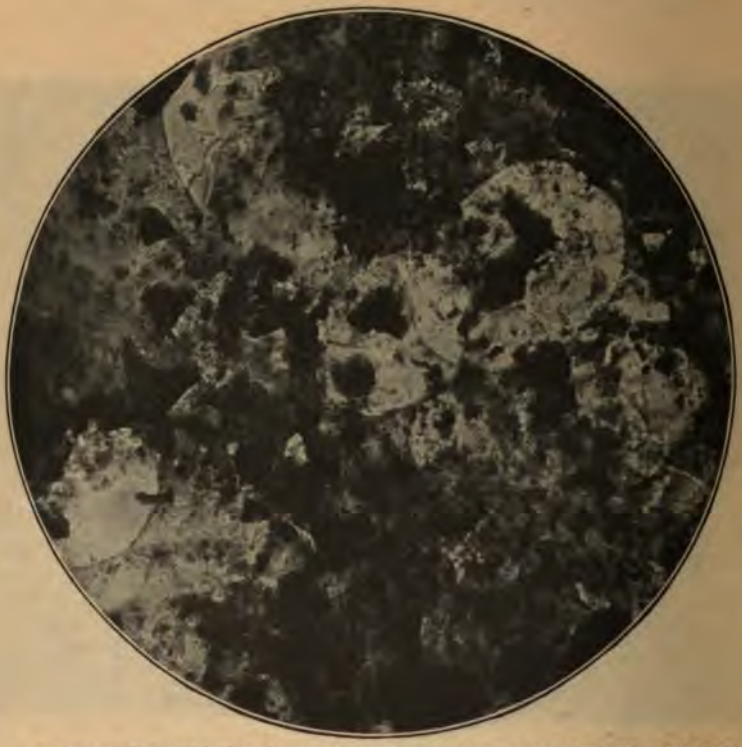


A. THIN HORIZONTAL SECTION OF COAL FROM THE OAK MINE, FIRST FOOT. (X 150)

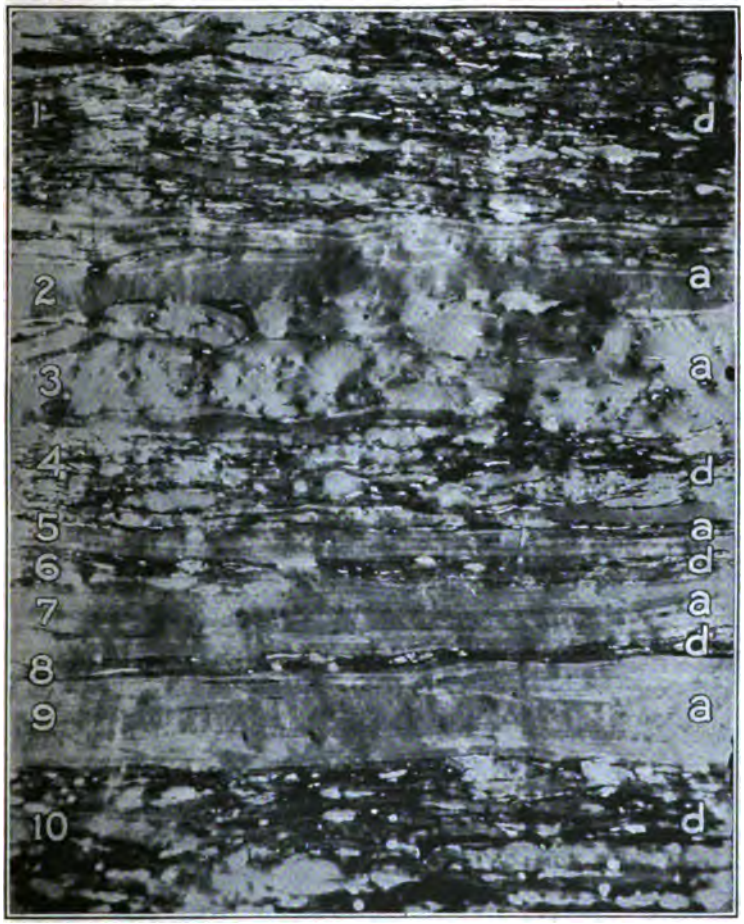


B. HIGHLY MAGNIFIED AREA FROM THE SECTION ABOVE. (X 1000)

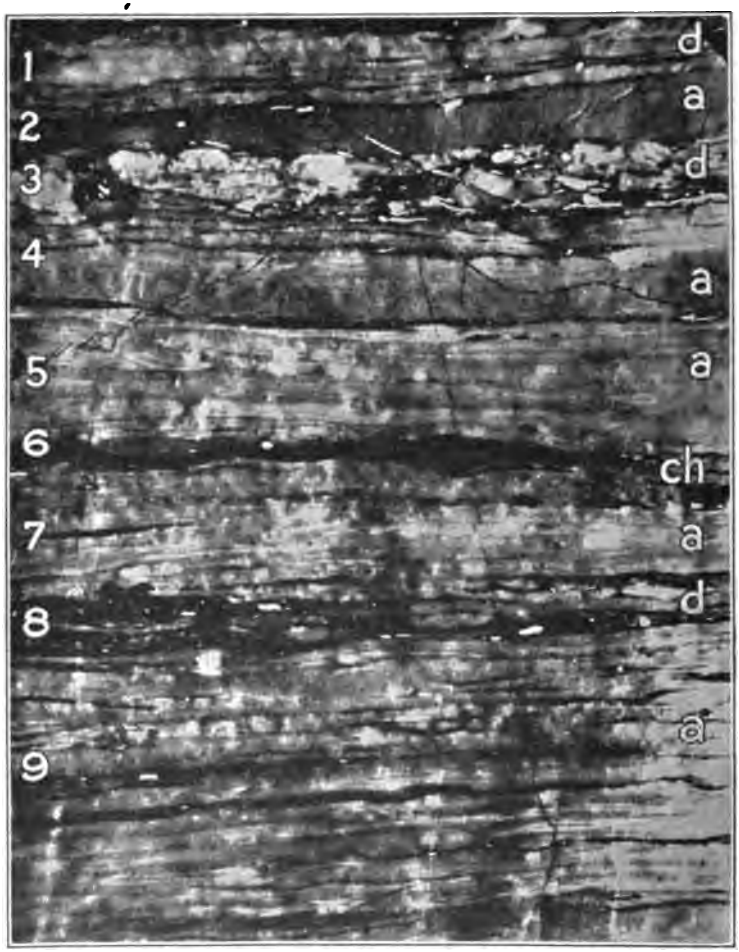
A. THIN HORIZONTAL SECTION OF COAL FROM THE OAK MINE, SECOND FOOT. (X 150)



B. AREA FROM SECTION SHOWN ABOVE, HIGHLY MAGNIFIED. (X 1000)



THIN VERTICAL SECTION OF COAL FROM THE EXPERIMENTAL MINE.
(X 200)



CONTINUATION FROM PLATE LXIII. (X 200)

PLATE LXV.

CONTINUED FROM PLATE LXIV.

The anthraxylon matter is here much disintegrated. There is no definite line of distinction between the anthraxylon chips and the humic matter in the finely divided state in which it forms a constituent of the attritus. Evidences of cell structure are seen in even the small particles.

PLATE LXVI.

CONTINUED FROM PLATE LXV.

This photograph shows a considerable amount of more highly carbonized matter; the anthraxylon matter is much disintegrated. Spore-exines are relatively few.

PLATE LXVII.

THIN VERTICAL SECTION.

A thin cross section from the coal from the Experimental mine (×200), showing an attritus rich in spore-exines, in which are embedded thin chips of anthraxylon, 2–a, 4–a, 6–a, and 8–a. A few particles of a more highly carbonized matter are shown.

PLATE LXVIII.

THIN VERTICAL SECTION.

A thin cross section (×200) of coal from the Experimental mine, showing a layer with much comminuted anthraxylon. The bark-like tissue at 2–a, in which the cell structure is well preserved, is common in some sections. It is dark brown, has a gummy appearance and irregular shapes. Although it is dark, its appearance differs altogether from that of the fragments of charcoal.

PLATE LXIX.

THIN VERTICAL SECTIONS.

A. A thin cross section of coal from the Experimental mine (×200) showing a strip of anthraxylon, 2–a, in which the cell structure is remarkably well preserved. The attritus at 3–d is very carbonaceous; the inclusion, shown in white, is a nest of intimately united spore-exines.

B. A thin cross section from the Pittsburgh coal at the experimental mine (×200), showing a typical appearance of the attritus in this coal, rich in humic matter and including a large number of spore-exines. The black ovoid area at 4–d represents one of the many highly carbonized, resinous globules in the coal.

PLATE LXX.

THIN VERTICAL SECTIONS.

A. A part of the section shown in Plate LXIX, *B* (×1,000), showing the distribution and nature of the components in detail. Spore-exines are represented by the linear white patches with a crenulated outline due to the sculpturing of the exine; the carbonaceous matter is in black and the humic matter in gray.

B. Another area included in the part of the cross section shown in Plate LXIX, *B* (×1,000), showing a larger amount of carbonaceous matter and a number of resinous particles in the attritus.

PLATE LXXI.

THIN HORIZONTAL SECTIONS.

A. A thin horizontal section of the coal from the Experimental mine (×150) shows the general appearance of a horizontal section through a layer of comminuted humic matter. Toward the right the section cuts off horizontally a thin slice of an anthraxylon chip. The large proportion of cell structures is noticeable.

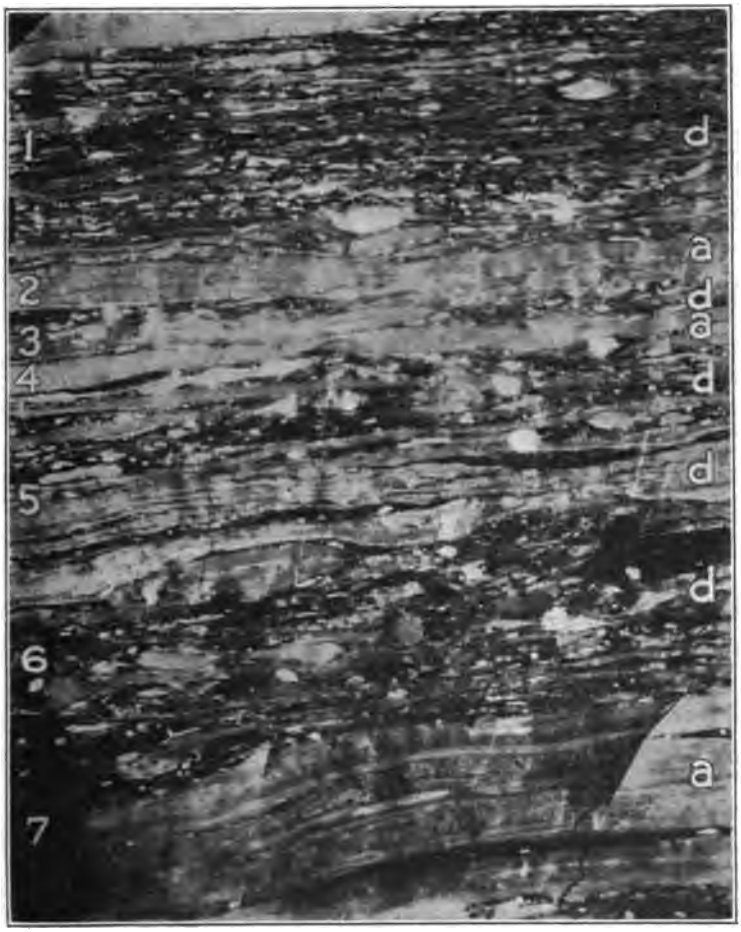
B. A thin horizontal section of the coal from the Experimental mine (×150) cut through humic attritus.

PLATE LXXII.

THIN HORIZONTAL SECTIONS.

A. A thin horizontal section of coal from the Pittsburgh seam at the Experimental mine (×150), showing a section cut horizontally through a vascular strand embedded in the attritus. Remnants of the spiral vessels are recognizable in the center of the strand.

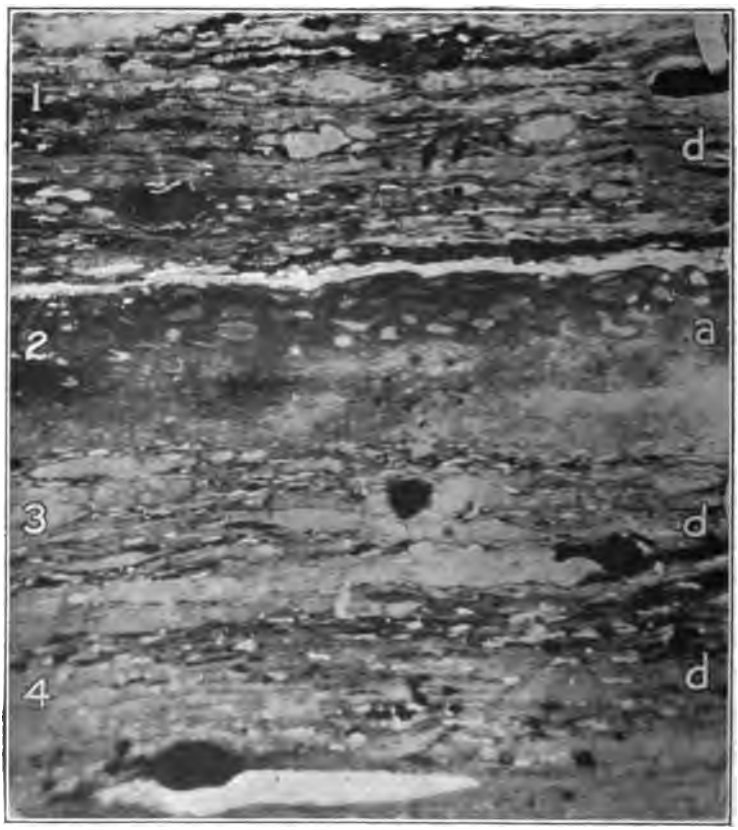
B. A thin horizontal section from the Pittsburgh coal at the Experimental mine (×150), showing a section through two overlapping anthraxylon chips; the cell structure, some of which is spiral, is clearly shown. Between the two chips is a vascular strand also showing spiral vessels.



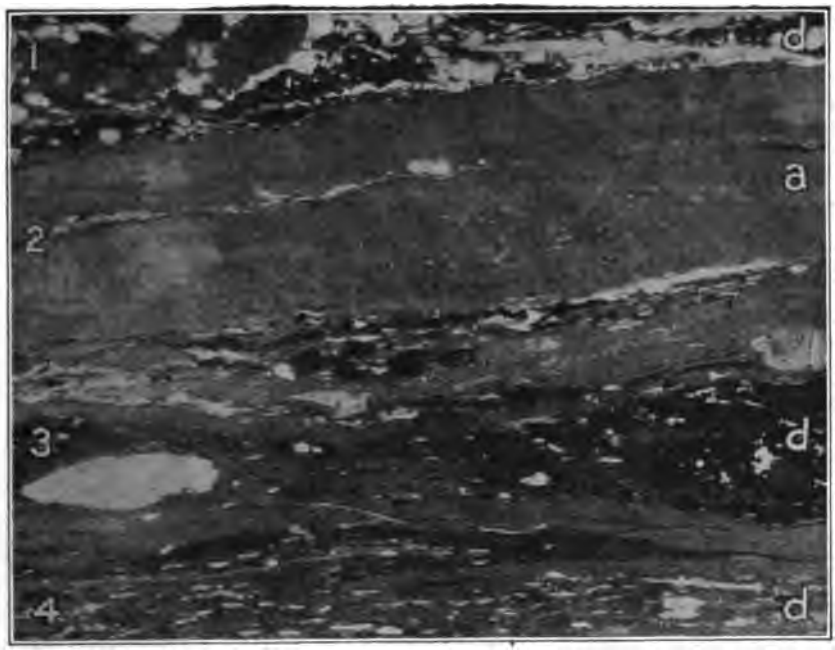
CONTINUATION FROM PLATE LXIV. (X 200)

CONTINUATION FROM PLATE LXV. (X 200)

THIN VERTICAL SECTION OF COAL FROM EXPERIMENTAL MINE, SHOWS SPORE-EXINES, ANTHRAXYLON CHIPS, AND MORE HIGHLY CARBONIZED MATTER. (X 200)

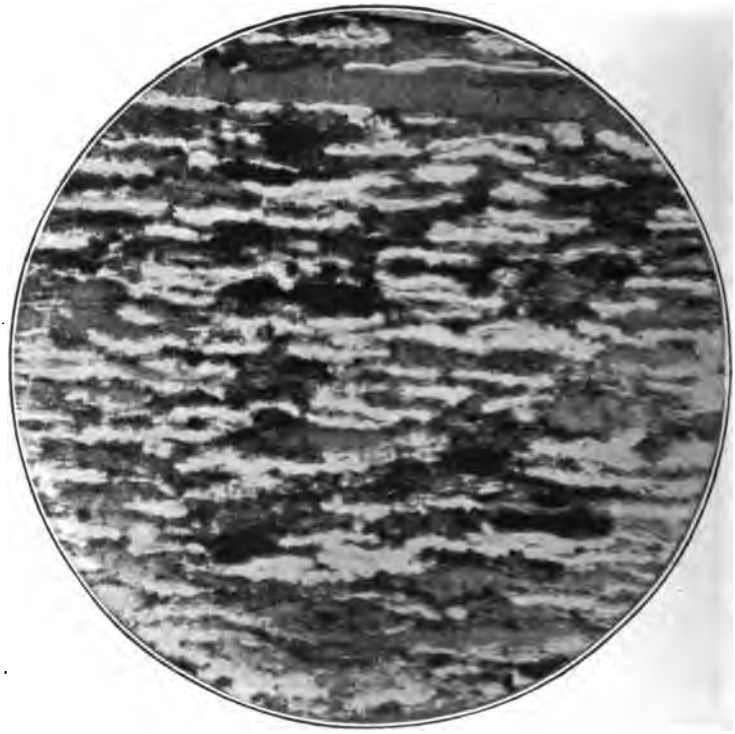


THIN VERTICAL-SECTION OF COAL FROM EXPERIMENTAL MINE, SHOWS MACERATED ANTHRAXYLON AND WELL PRESERVED BARK TISSUE. (×200)

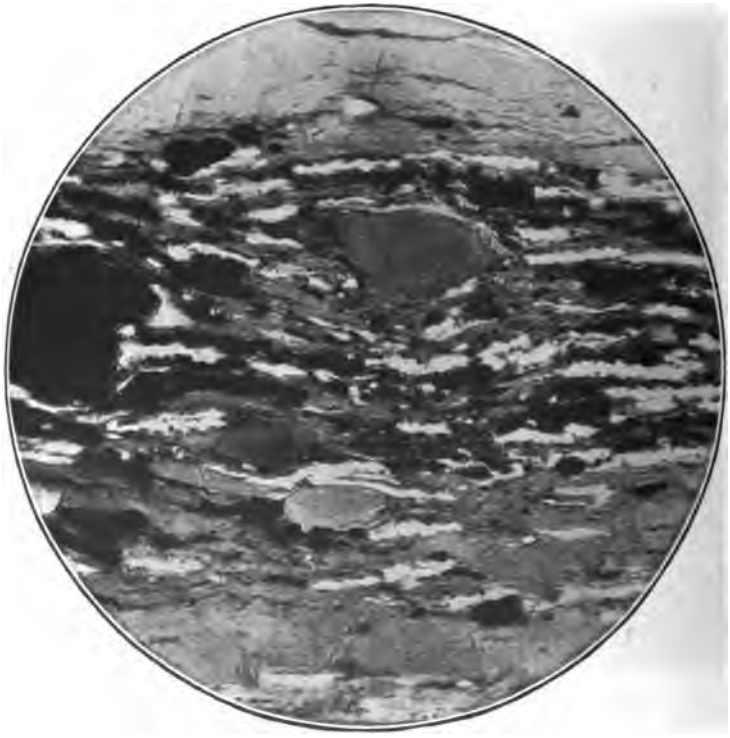


A. THIN VERTICAL SECTION OF COAL FROM THE EXPERIMENTAL MINE, SHOWING STRIP OF ANTHRAXYLON. (X 200)

B. THIN VERTICAL SECTION OF COAL FROM THE EXPERIMENTAL MINE, SHOWS TYPICAL APPEARANCE OF ATTRITUS. (X 200)

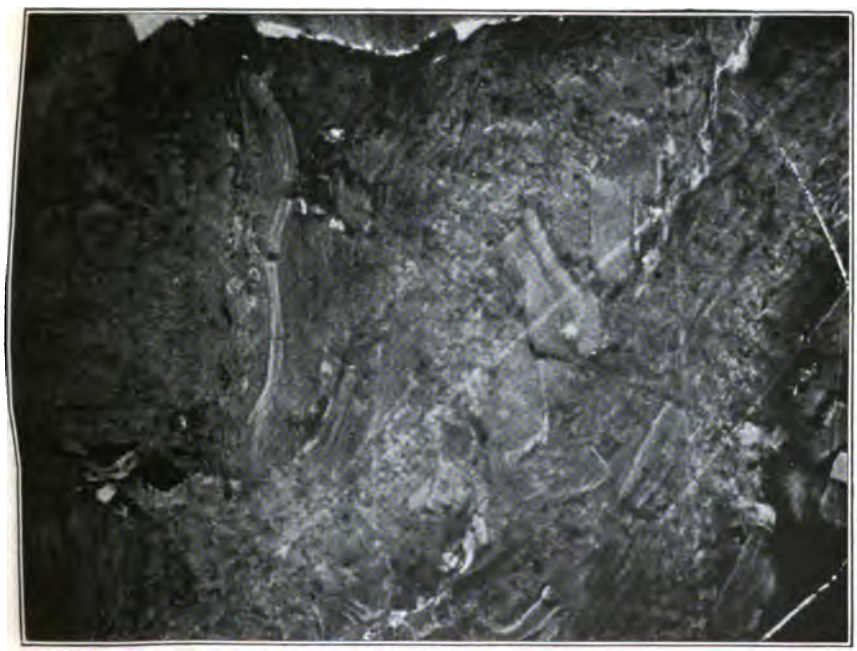


A. AREA FROM SECTION SHOWN IN PLATE LXIX, *B*. (X 1000)



B. ANOTHER AREA FROM SECTION SHOWN IN PLATE LXIX, *B*. (X 1000)

A. THIN HORIZONTAL SECTION OF COAL FROM THE EXPERIMENTAL MINE, CUT THROUGH HUMIC LAYER AND ANTHRAXYLON CHIP. (X 150)



B. THIN HORIZONTAL SECTION OF COAL FROM THEEXPERIMENTAL MINE, CUT THROUGH HUMIC ATTRITUS. (X 150)

A. VASCULAR STRAND EMBEDDED IN ATTRITUS, COAL FROM EXPERIMENTAL MINE. (X 150)

B. THIN HORIZONTAL SECTION OF COAL FROM EXPERIMENTAL MINE, CUT THROUGH TWO OVERLAPPING ANTHRAXYLON CHIPS. (X 150)

PLATE LXXIII.

THIN HORIZONTAL SECTIONS.

A. A thin horizontal section of the coal from the Experimental mine (×150), showing some of the very well-preserved tissues in this coal. The origin of the tissue embedded in the attritus is not clear, although it resembles in many ways the sporangium walls found in this and other coals.

B. A thin horizontal section of the coal from the Experimental mine (×150), showing a part of a sporangium wall, embedded in the attritus. A slice of an anthraxylon chip is shown in the upper part of the photograph.

PLATE LXXIV.

THIN HORIZONTAL SECTIONS.

A. A thin horizontal section of the coal from the Pittsburgh seam at the Experimental mine (×150), showing the general appearance of the attritus in horizontal sections. In the upper part is much disintegrated anthraxylon or humic matter, in the lower half the attritus is carbonaceous and also contains many spore-exines.

B. A horizontal section of the coal from the Experimental mine (×200), showing large resinous particles, partly covered by and seen through a thin section of anthraxylon on the left. At the upper right note the typical appearance of the attritus as seen in horizontal section; shown also in Plate LXXV, *A* (×1,000.)

PLATE LXXV.

THIN HORIZONTAL SECTIONS.

A. Horizontal section of part of the area shown in the upper right-hand corner of Plate LXXIV, *B* (×1,000), showing in detail the appearance and nature of the predominant spore-exines of the Pittsburgh coal and the general nature of the other constituents of the attritus.

B. A thin horizontal section of the coal from the Experimental mine (×1,000), showing the attritus partly through a thin slice of anthraxylon, the woody structure of which is evident. The elliptical spore-exine a little to the right of the center, with delicate spines arranged systematically over the surface, is scattered throughout the coal of the Pittsburgh bed.

PLATE LXXVI.

THIN HORIZONTAL SECTIONS.

A. A thin horizontal section (×1,000) of coal from the Experimental mine, through carbonaceous attritus. The definite particles of the carbonaceous matter are clearly shown. Under the microscope the humic matter is seen to be in a similar state of division, but on account of its refraction of the light the granular appearance is obscured.

B. From another thin horizontal section (×1,000) of coal from the Experimental mine, showing a condition similar to *A*. Note the great variability in size and form of the pollen-exines represented by the oval or ovoid areas.

PLATE LXXVII.

THIN VERTICAL SECTIONS.

A. A thin cross section of the Pittsburgh coal from Madison, Pa. (×200) showing the more highly carbonaceous nature of the attritus in the coal from this locality. The spore-exines are the same as those from other parts of the Pittsburgh bed. This photograph resembles Plate LIII, *A*, prepared from the coal from the Oak mine, and Plate LXIX, *B*, from the coal from the experimental mine, very closely.

B. An area near the center of *A* (×1,000), showing the constituents in detail.

PLATE LXXVIII.

THIN CROSS SECTIONS OF THE PITTSBURGH COAL.

A. A thin cross section of coal from the Pittsburgh seam from an unknown locality (×200), showing a strip of resinous anthraxylon, 2–a and 3–a, between the nonresinous strips 1–a and 4–a.

B. A thin cross section from coal of the Pittsburgh seam from an unknown locality (×200), showing a number of thin anthraxylon strips, 3–a, 5–a, and 7–a, and a carbonaceous attritus, 8–d. The spore-exines are of the same type as those of other localities of the seam.

PLATE LXXIX.

THIN VERTICAL SECTIONS.

A. A thin cross section (×200) of Pittsburgh coal from an unknown locality, showing a layer rich in humic matter and carbonaceous matter, and relatively few spore-exines. The humic matter consists largely of thin, flat particles.

B. A part of the section shown in *A* (×1,000), showing a considerable number of spore-exines, embedded in finely divided carbonaceous matter and some humic matter.

PLATE LXXX.

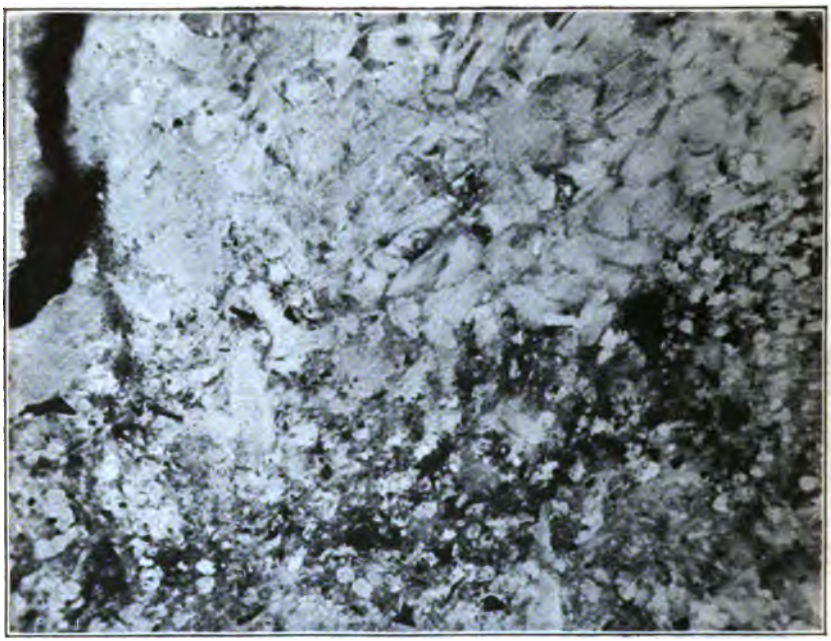
THIN VERTICAL SECTIONS.

A. A thin cross section (×200) of coal of the Pittsburgh seam from an unknown locality, showing a layer of attritus rich in humic matter, consisting largely of thin flat particles, numerous smaller carbonaceous particles, some resinous matter, and a considerable number of spore-exines. An area from this section is shown in Plate LXXXI, *A*. (×1,000.)

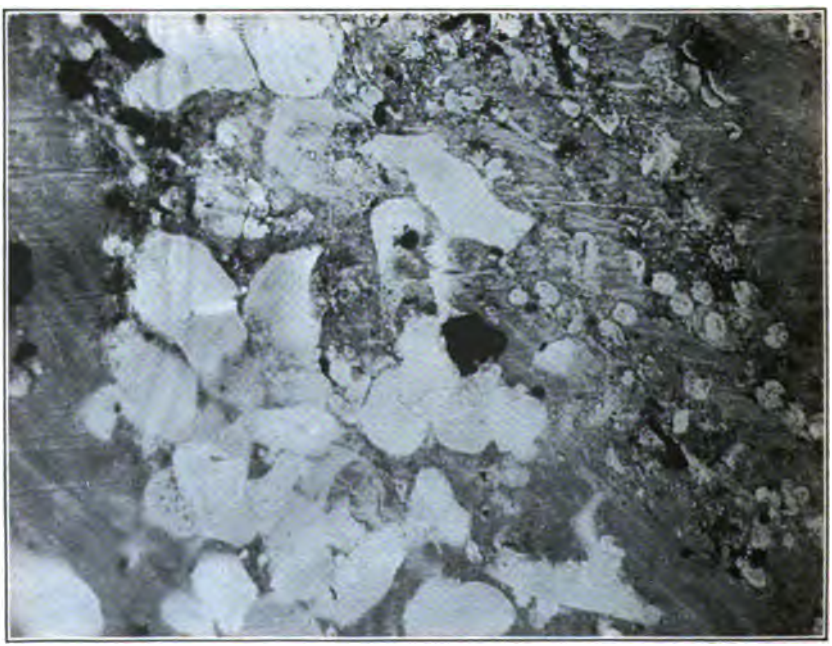
B. A part of the section shown in *A* (×1,000), showing the composition of the coal in detail. The anthraxylon strip in the upper part, although exceedingly thin, reveals remaining cell structures. Spore-exines are in white, carbonaceous matter in black, humic matter in gray.

A. TISSUES IN COAL FROM EXPERIMENTAL MINE. (X 150)

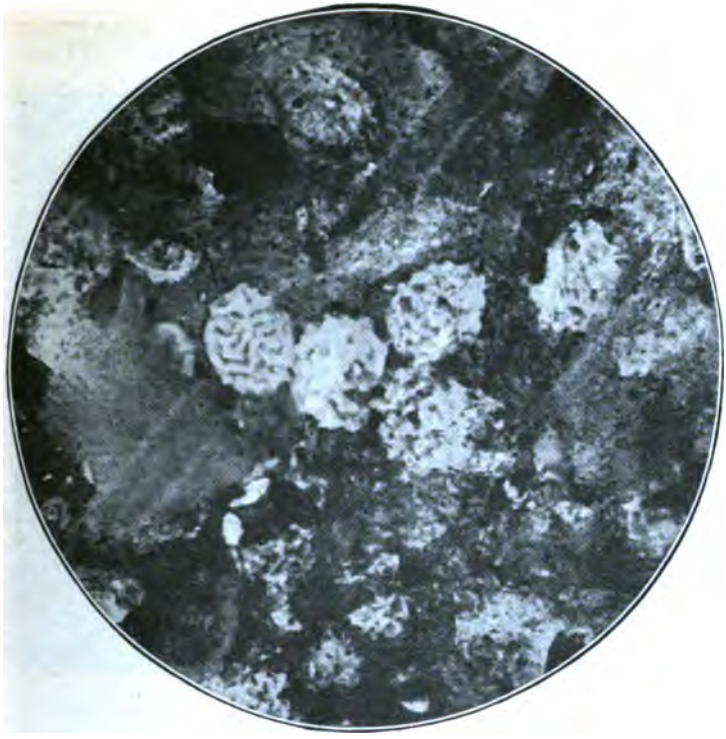
B. SPORANGIUM IN ATTRITUS, COAL FROM EXPERIMENTAL MINE. (X 150)



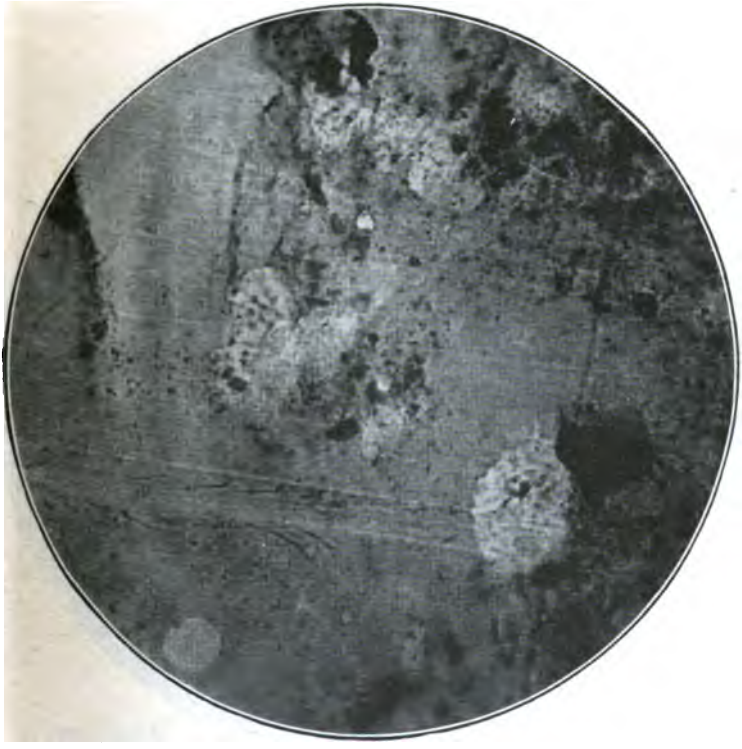
A. GENERAL APPEARANCE OF ATTRITUS, COAL FROM EXPERIMENTAL MINE. (X 150)



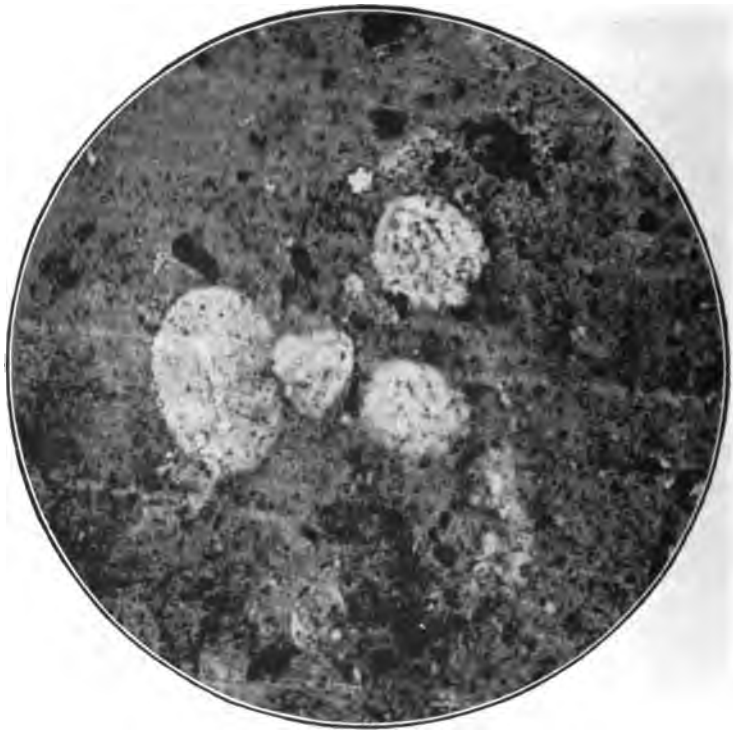
B. RESINOUS PARTICLES IN COAL FROM EXPERIMENTAL MINE. (X 200)



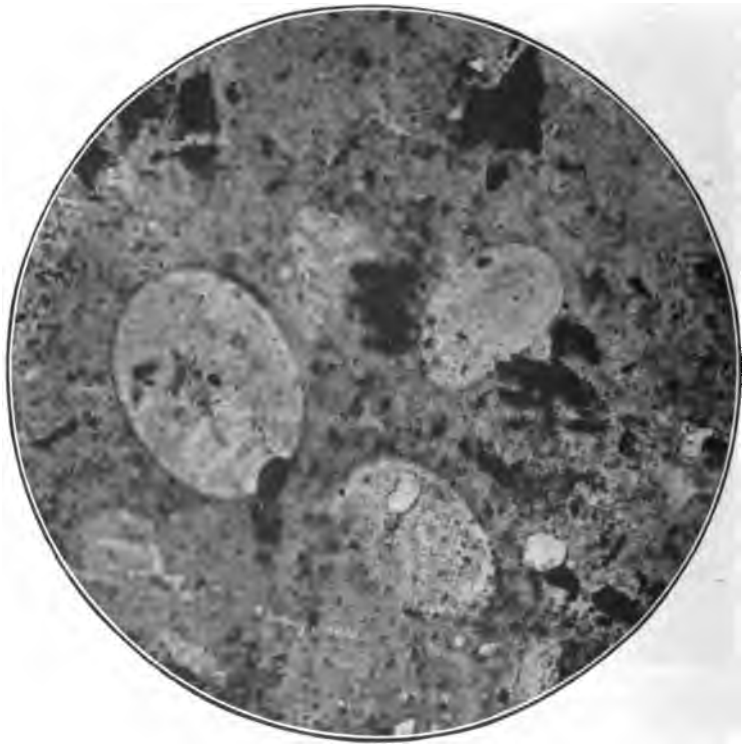
A. AREA FROM SECTION SHOWN IN PLATE LXXIV, *B*. (X 1000)



B. THIN HORIZONTAL SECTION OF COAL FROM THE EXPERIMENTAL MINE, SHOWING ANTHRAXYLON AND SPORE-EXINES IN ATTRITUS. (X 1000)

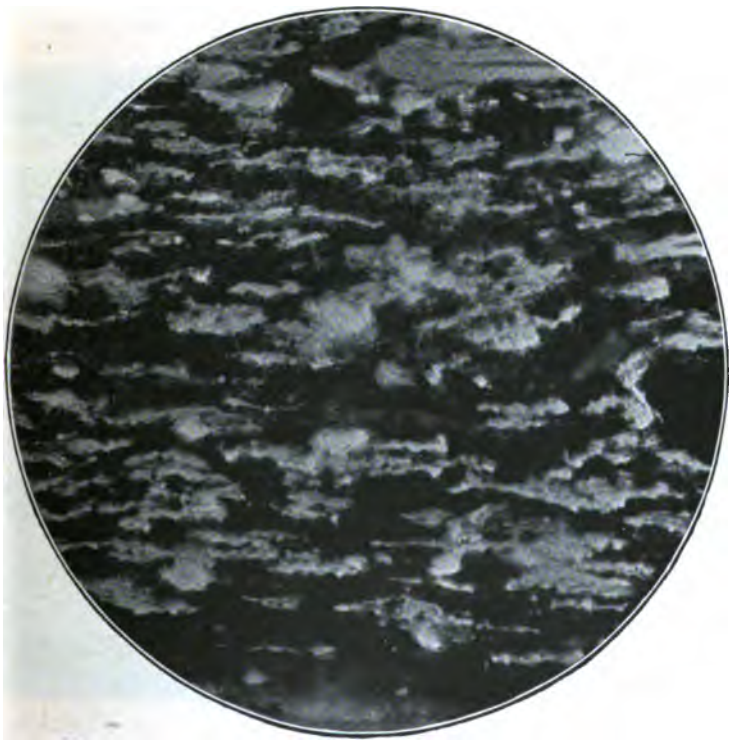


A. THIN HORIZONTAL SECTION (X 1000) OF COAL FROM THE EXPERIMENTAL MINE, THROUGH CARBONACEOUS ATTRITUS.

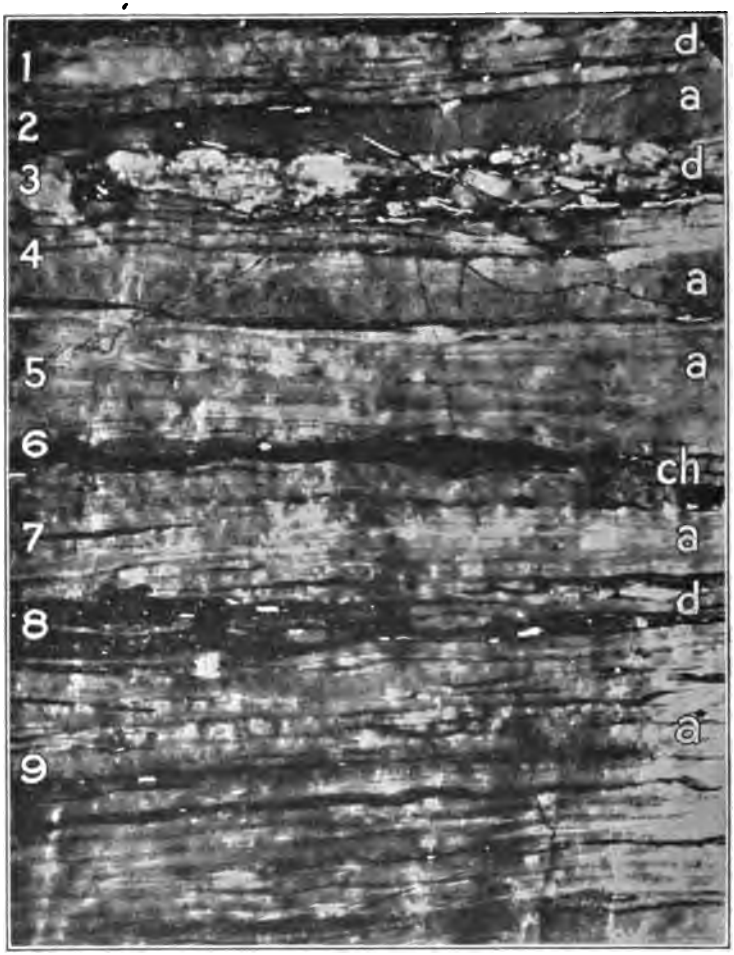


B. ANOTHER SECTION (X 1000) OF COAL FROM THE EXPERIMENTAL MINE, THROUGH CARBONACEOUS ATTRITUS.

A. THIN VERTICAL SECTION OF COAL FROM MADISON, PA. (X 200)



B. AREA FROM NEAR CENTER OF SECTION SHOWN ABOVE. (X 1000)



CONTINUATION FROM PLATE LXIII. (X 200)

PLATE LXV.

CONTINUED FROM PLATE LXIV.

The anthraxylon matter is here much disintegrated. There is no definite line of distinction between the anthraxylon chips and the humic matter in the finely divided state in which it forms a constituent of the attritus. Evidences of cell structure are seen in even the small particles.

PLATE LXVI.

CONTINUED FROM PLATE LXV.

This photograph shows a considerable amount of more highly carbonized matter; the anthraxylon matter is much disintegrated. Spore-exines are relatively few.

PLATE LXVII.

THIN VERTICAL SECTION.

A thin cross section from the coal from the Experimental mine (×200), showing an attritus rich in spore-exines, in which are embedded thin chips of anthraxylon, 2–a, 4–a, 6–a, and 8–a. A few particles of a more highly carbonized matter are shown.

PLATE LXVIII.

THIN VERTICAL SECTION.

A thin cross section (×200) of coal from the Experimental mine, showing a layer with much comminuted anthraxylon. The bark-like tissue at 2–a, in which the cell structure is well preserved, is common in some sections. It is dark brown, has a gummy appearance and irregular shapes. Although it is dark, its appearance differs altogether from that of the fragments of charcoal.

PLATE LXIX.

THIN VERTICAL SECTIONS.

A. A thin cross section of coal from the Experimental mine (×200) showing a strip of anthraxylon, 2–a, in which the cell structure is remarkably well preserved. The attritus at 3–d is very carbonaceous; the inclusion, shown in white, is a nest of intimately united spore-exines.

B. A thin cross section from the Pittsburgh coal at the experimental mine (×200), showing a typical appearance of the attritus in this coal, rich in humic matter and including a large number of spore-exines. The black ovoid area at 4–d represents one of the many highly carbonized, resinous globules in the coal.

PLATE LXX.

THIN VERTICAL SECTIONS.

A. A part of the section shown in Plate LXIX, *B* (×1,000), showing the distribution and nature of the components in detail. Spore-exines are represented by the linear white patches with a crenulated outline due to the sculpturing of the exine; the carbonaceous matter is in black and the humic matter in gray.

B. Another area included in the part of the cross section shown in Plate LXIX, *B* (×1,000), showing a larger amount of carbonaceous matter and a number of resinous particles in the attritus.

PLATE LXXI.

THIN HORIZONTAL SECTIONS.

A. A thin horizontal section of the coal from the Experimental mine (×150) shows the general appearance of a horizontal section through a layer of comminuted humic matter. Toward the right the section cuts off horizontally a thin slice of an anthraxylon chip. The large proportion of cell structures is noticeable.

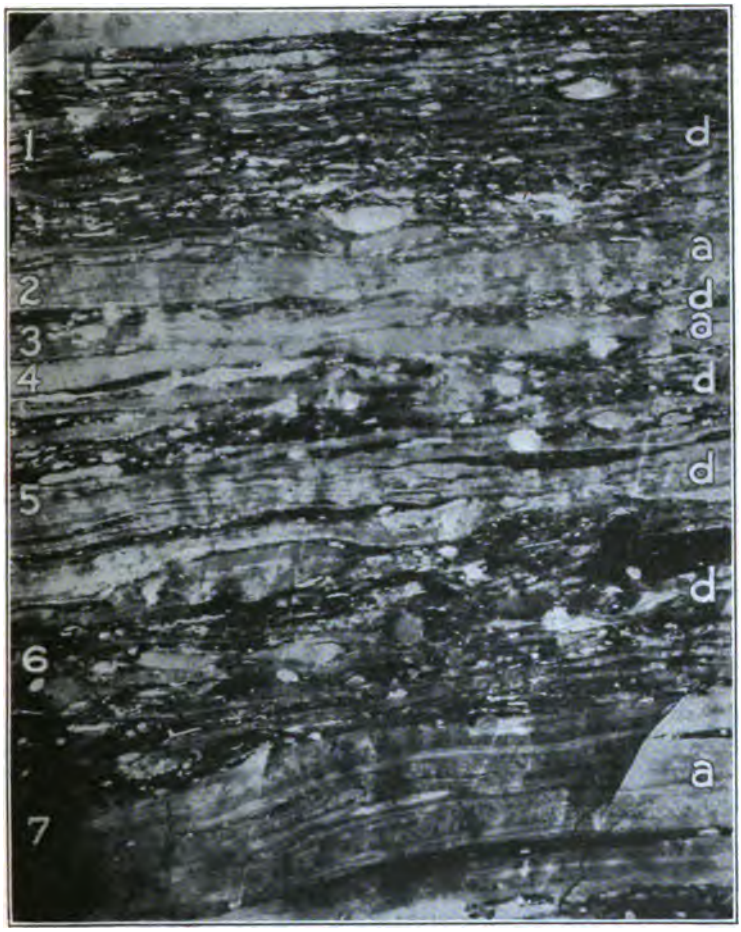
B. A thin horizontal section of the coal from the Experimental mine (×150) cut through humic attritus.

PLATE LXXII.

THIN HORIZONTAL SECTIONS.

A. A thin horizontal section of coal from the Pittsburgh seam at the Experimental mine (×150), showing a section cut horizontally through a vascular strand embedded in the attritus. Remnants of the spiral vessels are recognizable in the center of the strand.

B. A thin horizontal section from the Pittsburgh coal at the Experimental mine (×150), showing a section through two overlapping anthraxylon chips; the cell structure, some of which is spiral, is clearly shown. Between the two chips is a vascular strand also showing spiral vessels.



CONTINUATION FROM PLATE LXIV. (X 200)

PLATE LXXXV.

THIN VERTICAL SECTION.

A thin cross section (×200) of coal from Carbon Hill, Ala., showing an anthraxylous layer. The strip at 4–a has retained its cell structure remarkably well.

PLATE LXXXVI.

THIN VERTICAL SECTION.

A thin cross section (×200) of coal from Carbon Hill, Ala., showing a layer of humic attritus that includes a number of resinous particles, 2–d, few spore-exines, and little carbonaceous and earthy matter.

PLATE LXXXVII.

THIN VERTICAL SECTION.

A thin cross section (×200) of the coal from Carbon Hill, Ala., showing the character of the anthraxylon components often found in this coal. The woody structure at 1–a and 3–d is largely effaced, whereas at 2–a it is remarkably well preserved.

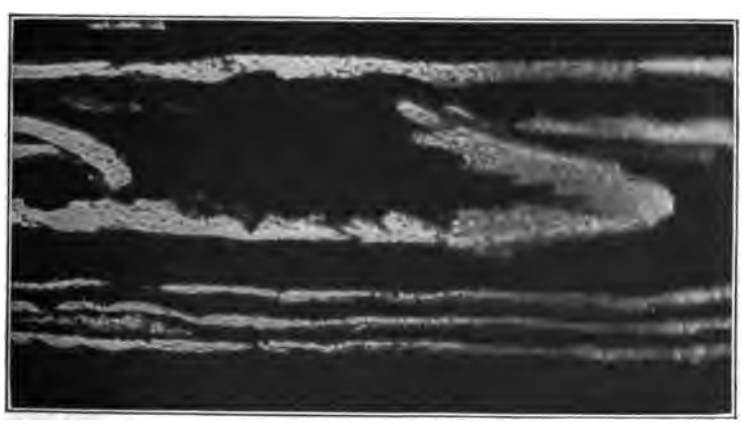
PLATE LXXXVIII.

THIN VERTICAL SECTIONS.

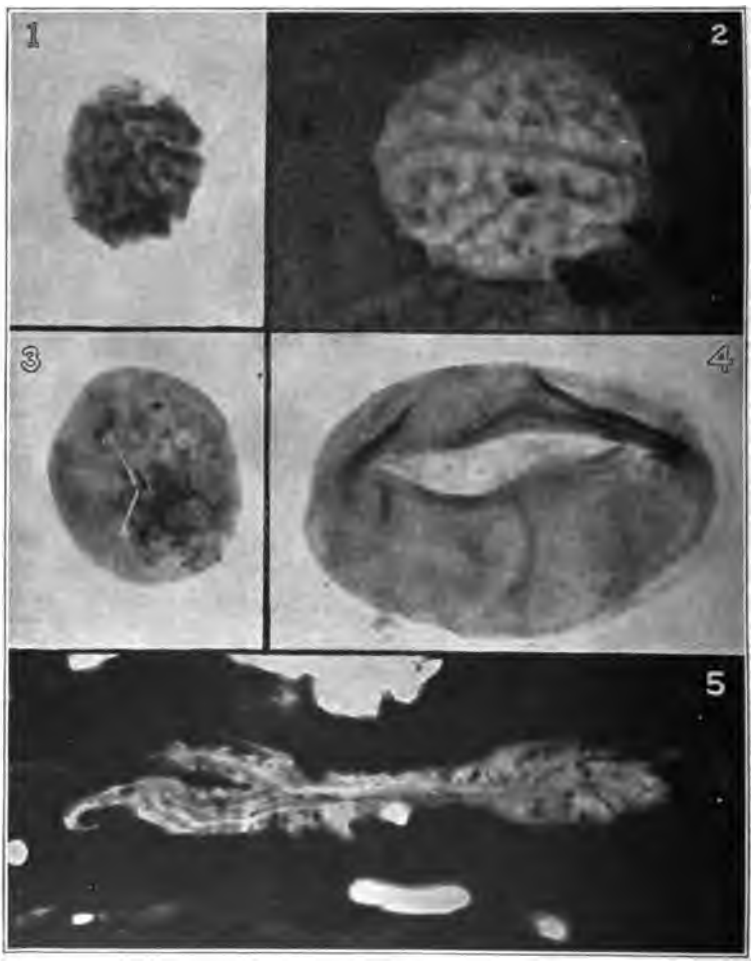
A. A typical thin cross section (× 200) of the attritus of the coal from Carbon Hill, Ala. As in other coals, no fast line of distinction can be drawn between the anthraxylon and the humic matter. The former is usually distinguished by its size and remains of cell structure.

B. A part of the section shown in *A* (× 1,000), showing the nature of the spore-exines in cross section. They differ from those of the Pittsburgh coal or those of any other bed.

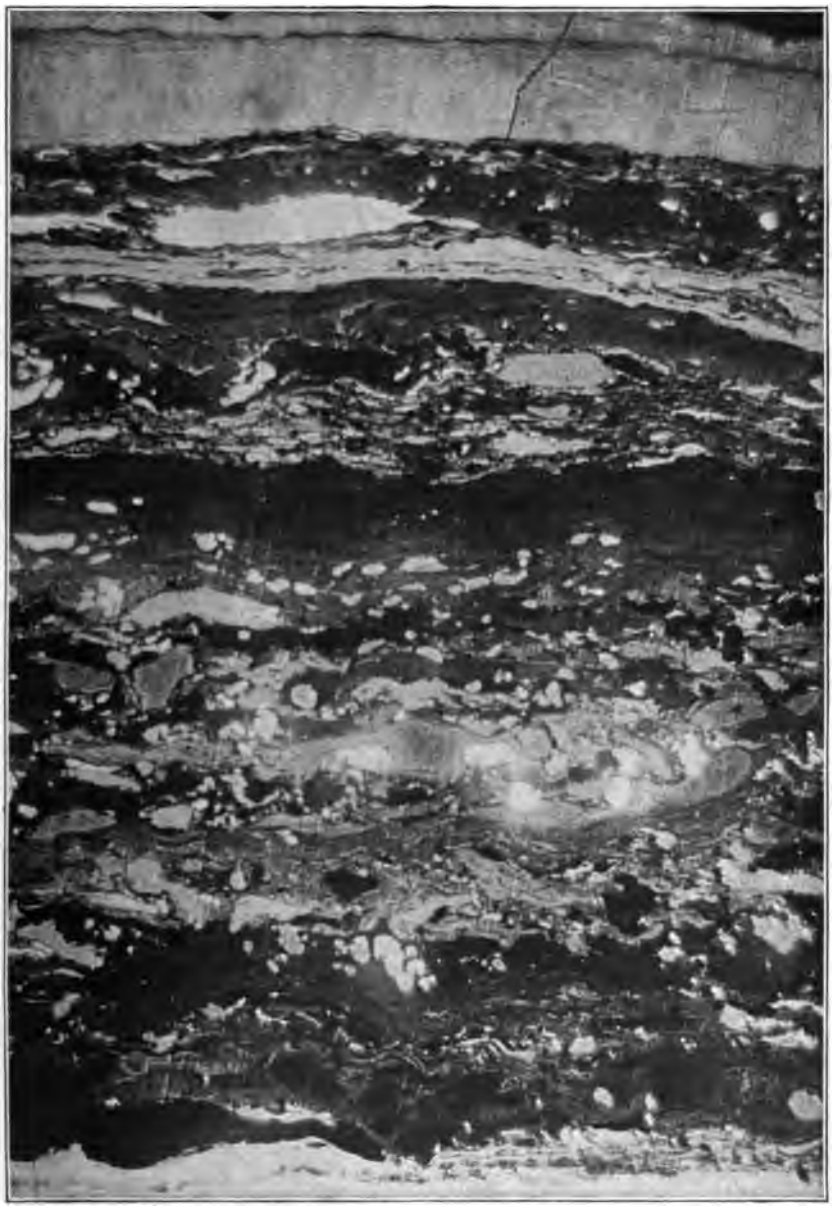
A. ANOTHER PART OF THE SECTION SHOWN IN PLATE LXXX, *A.* (X 1000)



B. THIN CROSS SECTION OF CUTICLE IN PITTSBURGH COAL. (X 200)

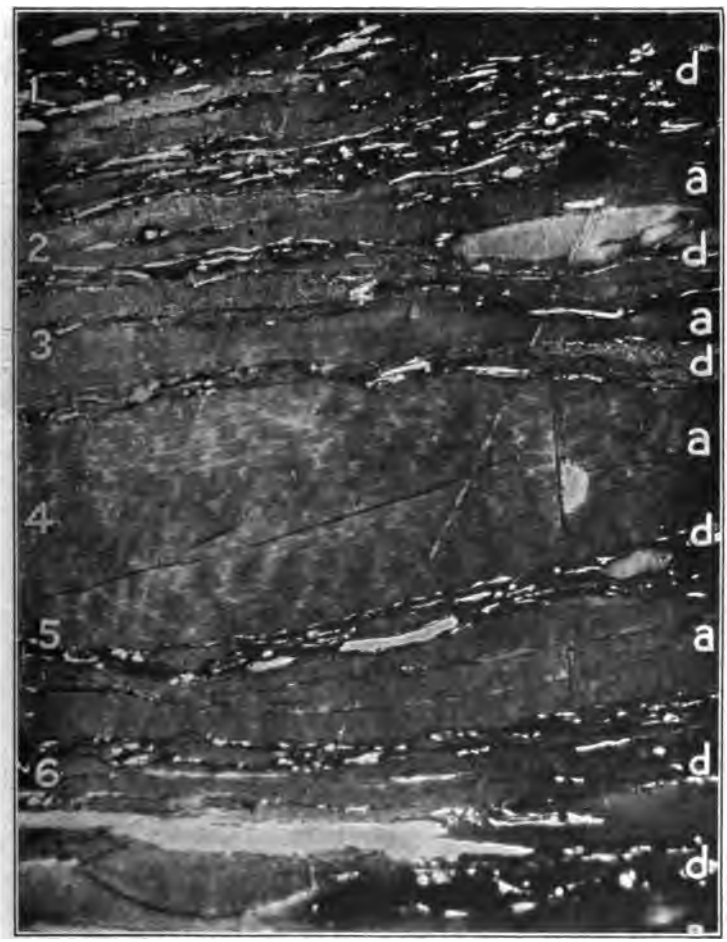


SPORE-EXINES AND A POLLEN GRAIN FROM THE PITTSBURGH COAL.
194



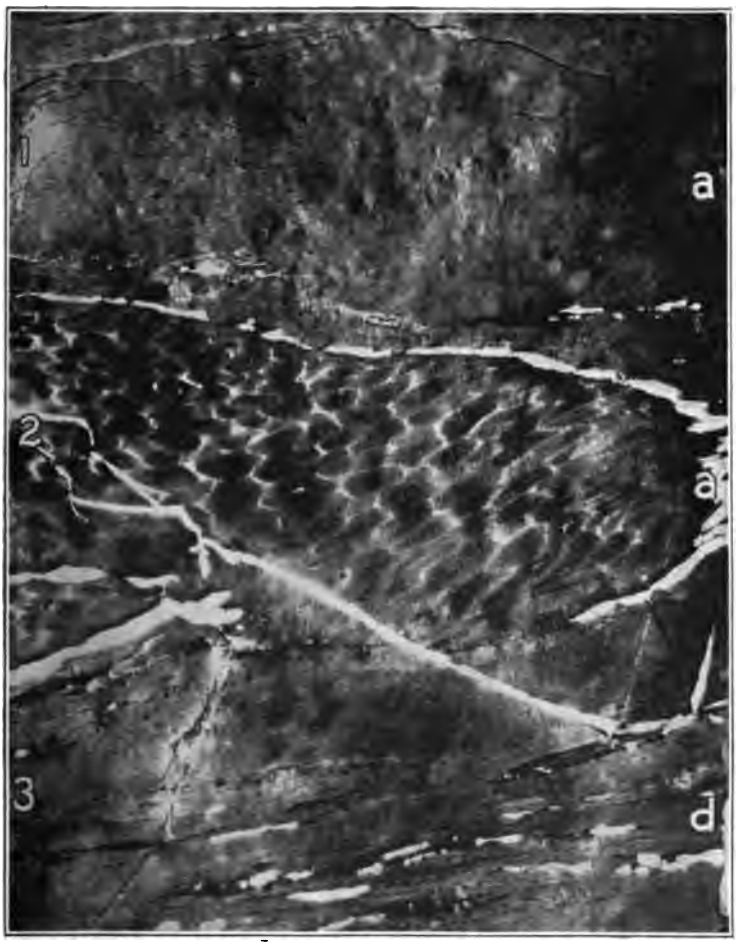
THIN VERTICAL SECTION OF PITTSBURGH COAL, SHOWING BARKLIKE TISSUES.

THIN VERTICAL SECTION OF COAL FROM CARBON HILL, ALA. (X 200)



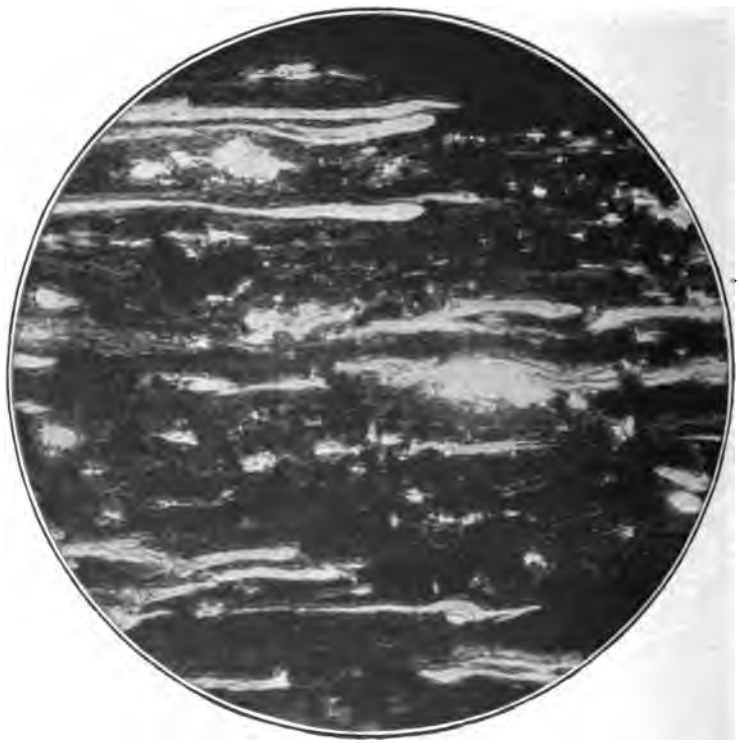
THIN SECTION OF COAL FROM CARBON HILL, ALA., SHOWING AN ANTHRAXYLOUS LAYER. (X 200)

THIN VERTICAL SECTION OF COAL FROM CARBON HILL, ALA., SHOWING A LAYER OF HUMIC ATTRITUS. (X 200)



THIN VERTICAL SECTION OF COAL FROM CARBON HILL, ALA., SHOWING CHARACTER OF ANTHRAXYLON COMPONENTS. (X 200)

A. TYPICAL CROSS SECTION OF ATTRITUS OF COAL FROM CARBON HILL, ALA. (X 200)



B. PART OF THE SECTION SHOWN ABOVE. (X 1000)

PLATE LXXXIX.

THIN VERTICAL SECTIONS.

A. A thin cross section of coal from the mine of the Hart-Williams Coal Co., near Benton, Ill. (× 200), showing a part of a lamina of attritus composed of about equal amounts of humic matter, spore-exines, and carbonaceous matter. The strips at 2–a and 4–a represent thin chips of anthraxylon.

B. A part of the section illustrated in *A* (× 1,000), showing the nature of the constituents in detail. Spore-exines are in white, humic matter and anthraxylon in gray, and carbonaceous and earthy matter in black. The remains of the cell structure in the anthraxylon chip in the lower part are shown by striations.

PLATE XC.

THIN VERTICAL SECTIONS.

A. and *B*. Parts of thin sections of coal from the Hart-Williams mine (× 1,000), showing the nature of the humic matter, carbonaceous matter, and the types of spore-exines found in this coal. Three types may easily be observed.

PLATE XCI.

THIN VERTICAL SECTION.

A. A thin vertical section of a larger anthraxylon component of the Hart-Williams coal. At a lower magnification this component appeared perfectly homogeneous, but at the magnification shown remaining cell structure is distinctly seen.

B. A cross section of coal from the mine of the Benton Coal Co., showing its general appearance. The anthraxylon strips, 2–a, 4–a, and 6–a, are compact and vitreous and reveal hardly any structure in cross section. In horizontal sections, however, the cell structure is clearly seen. The attritus consists of humic matter, some spore-exines, a little carbonaceous and earthy matter and much resinous matter.

PLATE XCII.

THIN VERTICAL SECTIONS.

A. A thin cross section of the coal from the Zeigler mine, Zeigler, Ill., showing the character of a larger anthraxylon component or bright coal, in cross section. The cell structure has been largely obliterated but is still recognizable; the fibers have been much flattened and intimately united. The piece is resinous, but the resinous inclusions are not well shown because in color and consistency they are much like the enveloping anthraxylon matter.

B. A typical thin cross section (×200) of the Zeigler coal. The striations in the anthraxylon strip, 1–a are due to collapsed and intimately united cells. The remainder of the photograph represents a layer composed of many leaf cuticles, the residue of leaf tissues, spore matter, resinous and humic matter, and a tissue of a cork-like nature, particularly well represented at 3–d; a similar tissue is shown at a higher magnification in Plate CX, *B*.

PLATE XCIII.

THIN VERTICAL SECTIONS.

A. A thin cross section of the Zeigler coal, representing strips of anthraxylon. The strip 3–a is of the common type, in which the cells are much flattened and intimately united. 1–a is gnarly and granular and includes very large resinous particles.

B. A thin cross section of the Zeigler coal, showing at 1–a part of a decidedly homogeneous anthraxylon component in which cell structures are obscured. The presence of the structures can be demonstrated by various methods of illumination. The area 2–d to 4–d is composed of thin anthraxylon strips in which cell structures are clearly visible, containing a relatively large proportion of the cork-like tissue, other humic matter, and spore-exines.

PLATE XCIV.

THIN VERTICAL SECTIONS.

A. A typical thin cross section (×200) of the Zeigler coal. 1–d is a row of spore-exines; 2–a is a lamina of closely packed anthraxylon chips, homogeneous in appearance, in which the original cells may be recognized. At 3–d is a thin, light-colored lamina of spore-exines, and at 4–d to 5–d a lamina composed of cork-like tissue, resinous degradation matter, leaf cuticles, and humic matter.

B. A thin cross section (×200) of the Zeigler coal, showing the general nature of certain laminæ of the coal. At 1–d is a thin lamina composed of humic matter, spore-exines, and some of the cork-like tissues; just below this, at 2–c, are several cuticles and some spore-exines; at 2–a are anthraxylon strips. This is shown at higher magnification in Plate XCVI, *A* and *B*. The remainder of the photograph shows attritus containing resinous matter, anthraxylon strips, humic matter, cuticles, and spore-exines. Notice the unusually small amount of carbonaceous matter.

PLATE XCV.

THIN VERTICAL SECTIONS.

A. Part of the section shown in Plate XCIV, *B* (×1,000), taken from the middle of level 1–d, and showing spore-exines, humic matter, cork-like tissue, cuticles, and resinous particles in detail.

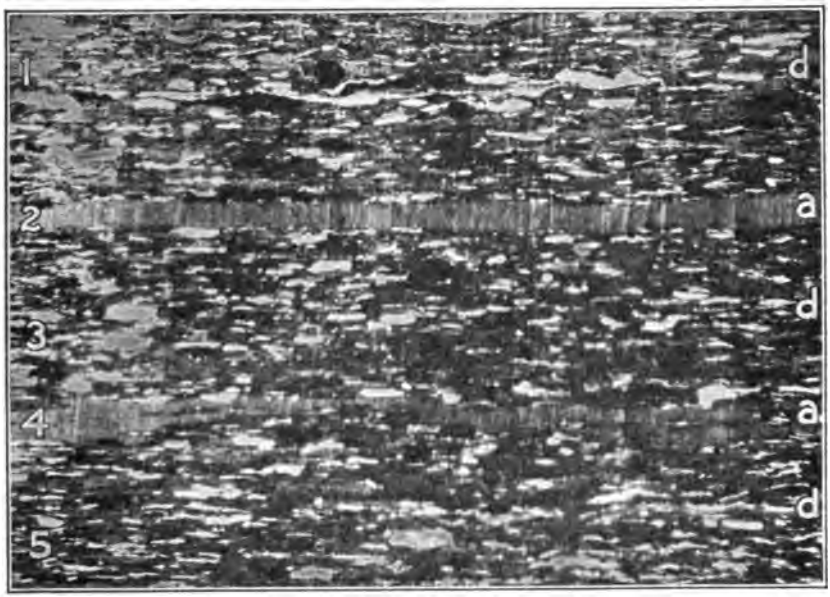
B. Part of the section shown in Plate XCIV, *B*, taken from the level 6–d. (×1,000.)

PLATE XCVI.

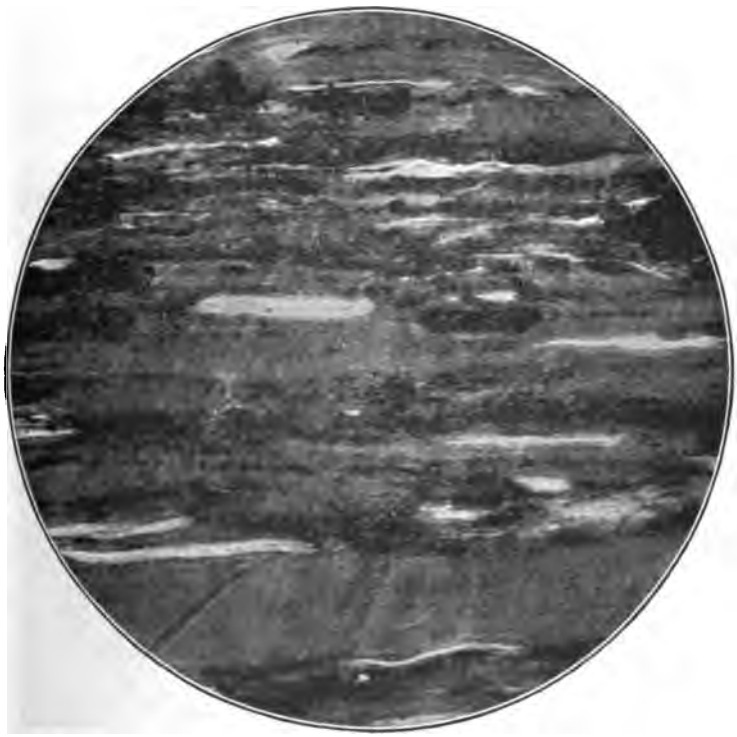
THIN VERTICAL SECTIONS.

A. Part of an area just outside of Plate XCIV, *B* (×1,000), representing a humic lamina including several spore-exines and delicate cuticular matter.

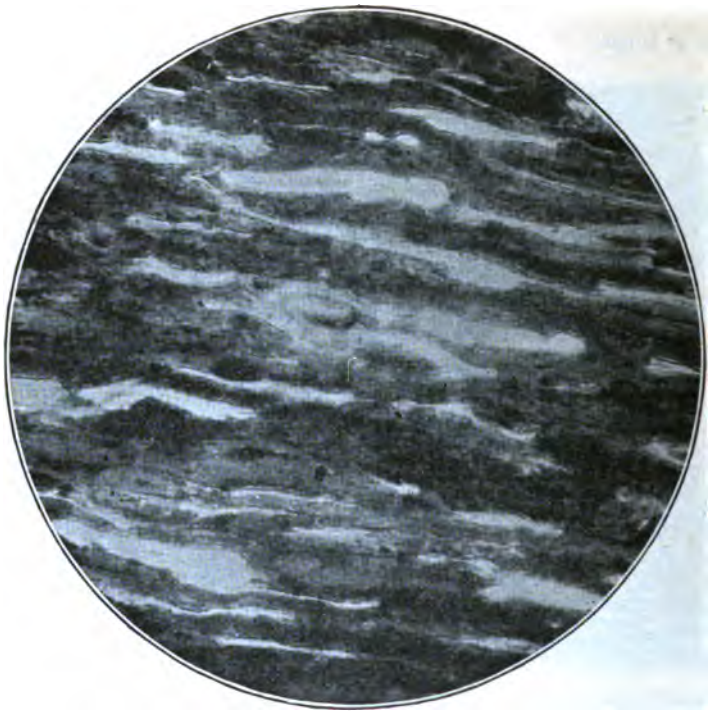
B. Part of the same area (×1,000), representing humic matter including several characteristic thick walled spore-exines, thin-walled exines, and cuticular matter.



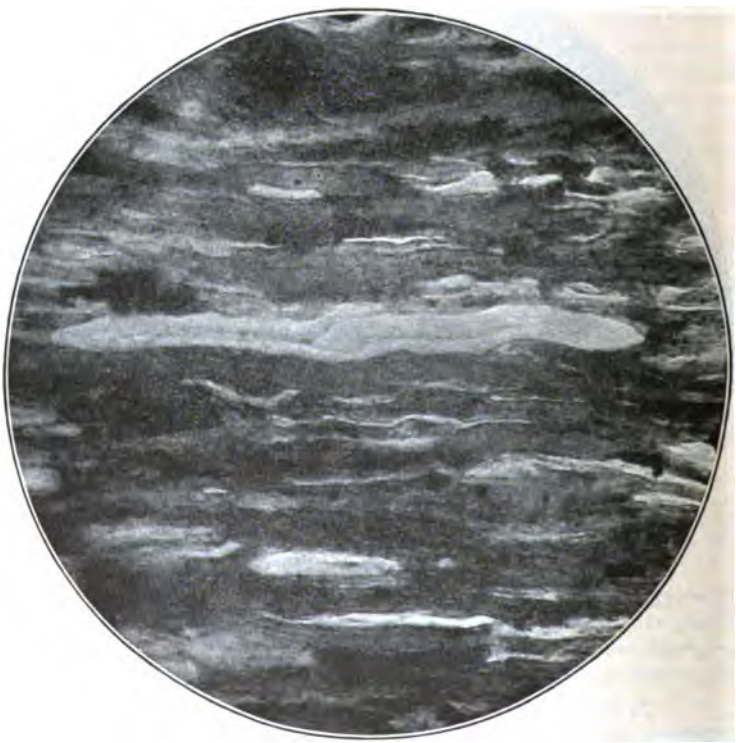
A. THIN VERTICAL SECTION OF COAL FROM THE HART-WILLIAMS MINE. (X 200)



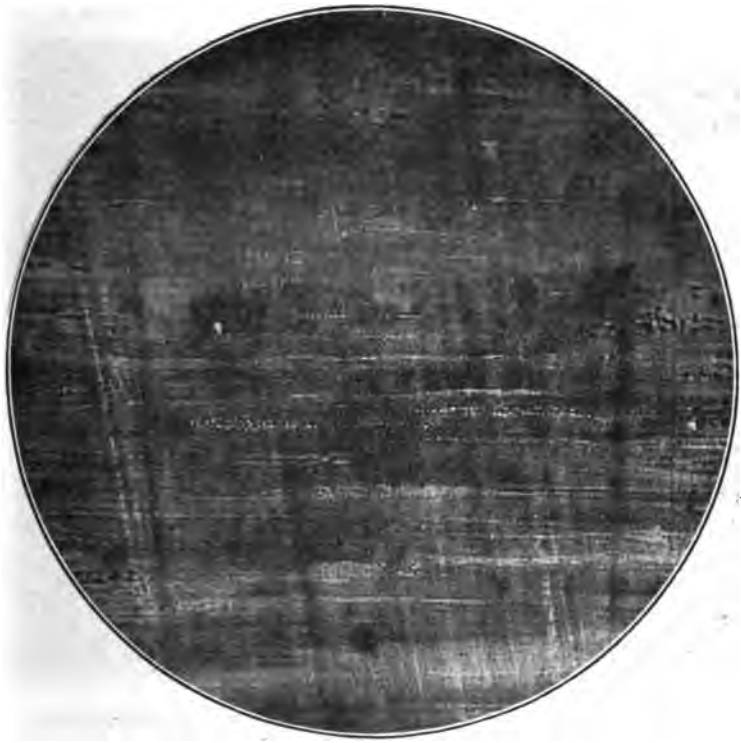
B. PART OF THE SECTION SHOWN ABOVE. (X 1000)



A. PART OF A THIN VERTICAL SECTION OF COAL FROM THE HART-WILLIAMS MINE. (X 1000)



B. ANOTHER PART OF A THIN VERTICAL SECTION OF COAL FROM THE HART-WILLIAMS MINE. (X 1000)



A. THIN VERTICAL SECTION OF ONE OF THE LARGER ANTHRAXYLON COMPONENTS IN COAL FROM THE HART-WILLIAMS MINE, BENTON, ILL.

B. THIN VERTICAL SECTION OF COAL FROM THE BENTON MINE, BENTON, ILL., SHOWING GENERAL APPEARANCE.

A. THIN VERTICAL SECTION OF COAL FROM ZEIGLER, ILL.

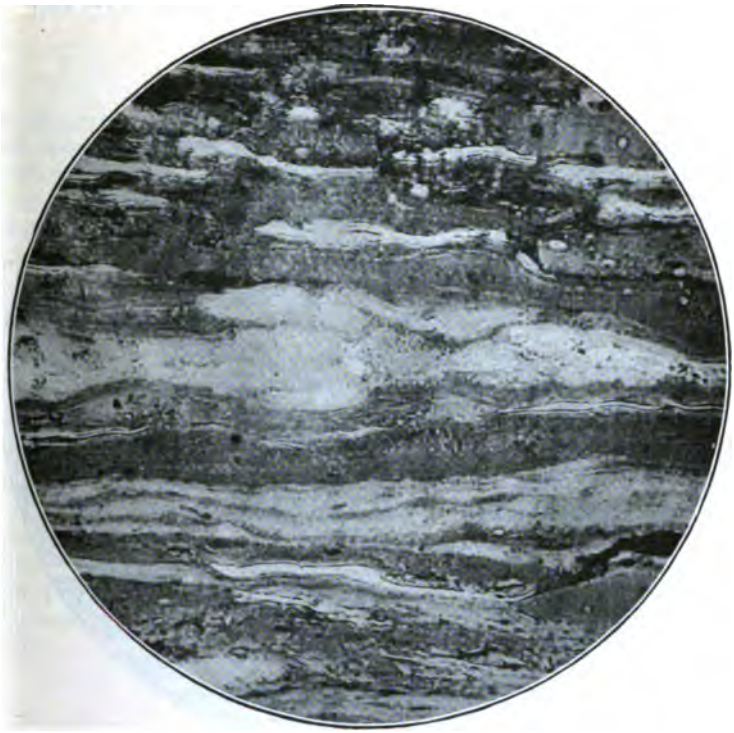
B. TYPICAL CROSS SECTION OF THE ZEIGLER COAL. (X 200)

A. THIN VERTICAL SECTION OF ZEIGLER COAL, SHOWING STRIPS OF ANTHRAXYLON.

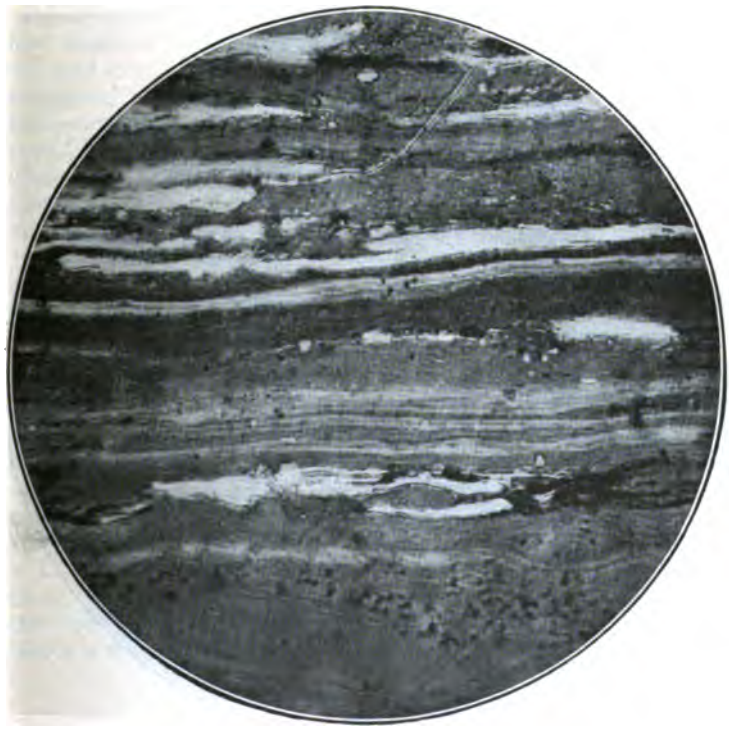
B. THIN VERTICAL SECTION OF ZEIGLER COAL, SHOWING ANTHRAXYLON STRUCTURE.

A. THIN VERTICAL SECTION OF COAL FROM ZEIGLER, ILL., SHOWING TYPICAL LAMINATION. (X 200)

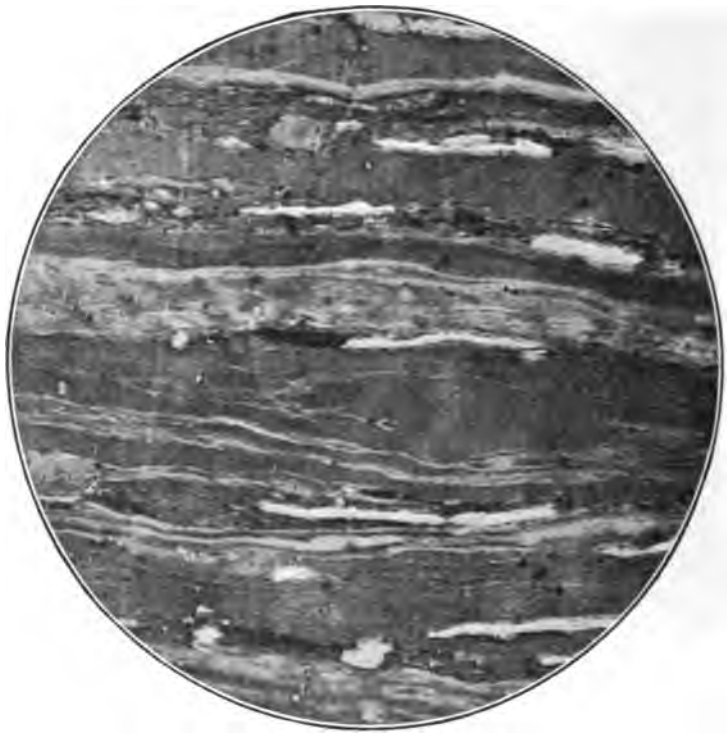
B. THIN VERTICAL SECTION OF ZEIGLER COAL, SHOWING GENERAL CHARACTER OF CERTAIN LAMINAE. (X 200)



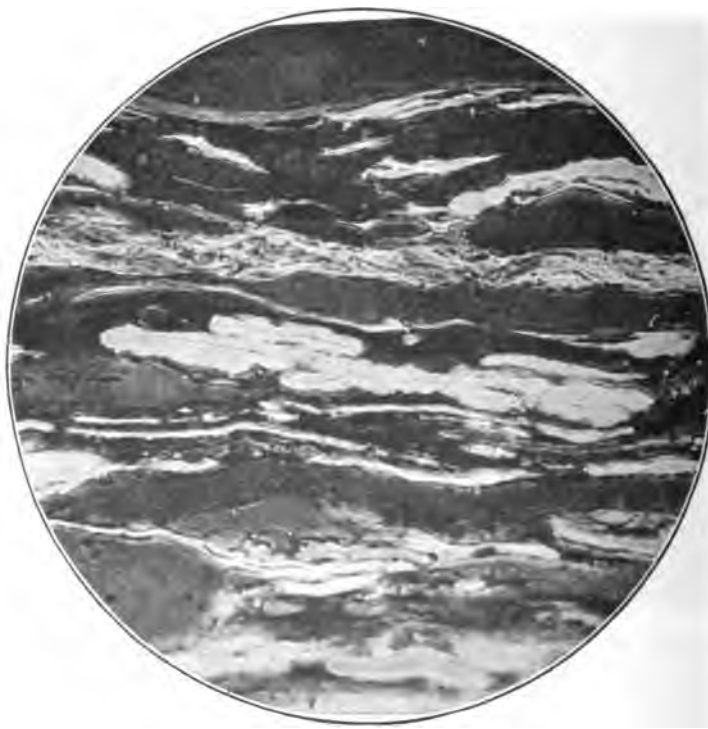
A. PART OF THE SECTION SHOWN IN PLATE XCIV, *B*, FROM THE MIDDLE OF LEVEL 1-D. (X 1000)



B. PART OF THE SECTION SHOWN IN PLATE XCIV, *B*, FROM THE LEVEL 6-D. (X 1000)



A. PART OF AN AREA JUST OUTSIDE THE SECTION SHOWN IN PLATE XCIV, *B*. (X 1000)



B. PART OF THE SAME AREA REFERRED TO ABOVE. (X 1000)

PLATE XCVII.

THIN VERTICAL SECTION.

A. A thin cross section of the Zeigler coal (×200) representing a layer of humic attritus. 1–d is a resinous humic lamina; at 2–sp are a number of closely packed spore-exines; at 3–d is a lamina composed of resinous-appearing humic matter and thick-walled spore-exines.

B. A part of the lamina 3–d in *A* (×1,000), showing the thick-walled spore-exines, humic matter, light thin-walled tissues and resinous matter.

PLATE XCVIII.

THIN VERTICAL SECTION.

A. A thin cross section (×200) of a layer of coal of an Illinois coal composed largely of cuticles and other degradation products of leaves, similar to that shown in Plate XXIV, *A*. The cuticles form irregular, somewhat saw-edged, narrow white bands; the degradation matter derived from the leaf tissues form mottled bands between the cuticles.

B. Thin cross section (×200) of a layer of an Illinois coal similar to that shown in *A* showing pairs of cuticles, that is, the upper and the lower cuticles, closely united with no attritus between.

PLATE XCIX.

THIN HORIZONTAL SECTIONS.

A. A thin horizontal section of the Zeigler coal (×150), showing the general appearance of the coal in horizontal section. The part of the section represented shows a slice of anthraxylon partly covering the attritus. The small oval and circular, whitish particles represent spore and pollen exines. The anthraxylon, in which the wood fibers are recognizable, is shaded gray, the carbonaceous matter, black.

B. Another thin horizontal section of the Zeigler coal (×150), showing anthraxylon matter in which the remaining wood fibers are distinctly seen; separate fibers are shown in the attritus in the central and upper parts of the photograph.

PLATE C.

THIN VERTICAL SECTIONS.

A. A thin cross section of the coal from Sesser, Ill. (×10). 1–d, 2–d, and 4–d represent the "dull coal," and 3–a a strip of "bright coal" or anthraxylon. As in other coals the "dull coal" is composed of thin anthraxylon sheets or strips embedded in attritus. The fine white specks represent chiefly microspore-exines, and the short thick white lines represent megaspore-exines.

B. A part of the section shown in *A* (×200). At 3–a is one of the thin strips of anthraxylon embedded in the attritus 2–d in *A*, showing resinous contents and also the remaining cell structure; 1–d is attritus composed mostly of thin walled tissues, including cuticular matter; at 2–sp is a row of large thin-walled spore-exines; at 4–a is a part of a cuticle. In the carbonaceous lamina 5–d is a fragment of a megaspore-exine.

PLATE CI.

THIN VERTICAL SECTIONS.

A. Part of a cross section of "bright coal" or larger anthraxylon component (×200), representing a type of woody tissue found in all the coals examined. The section here represented is from the "bright coal" shown at 2–a in Plate XXIV, *B*. A similar structure is also shown in Plate CXIV, *A*, of the Shelbyville coal and in Plate LIX, *B*, of the Pittsburgh coal.

B. A more highly magnified portion of the section shown in *A* (×1000). The tissue shows bands similar to those of the annual growth rings of living plants. Small thick-walled cell fibers are visible.

PLATE CII.

THIN VERTICAL SECTIONS.

A. The large, relatively thin-walled and resin-filled area of the section shown in Plate CI, *A*, (×1000). See also Plate CXIV, *A* and *B*.

B. A cross section of another strip of "bright coal," or anthraxylon (×200). This type of structure is abundant in the Paleozoic coals examined, and the state of preservation is common.

PLATE CIII.

THIN VERTICAL SECTIONS.

A. A thin cross section of the coal from Sesser, Ill. (×200), from an anthraxylous section with a resinous attritus at 1–d. The resinous matter is peculiar and not like resinous particles in other coals. The humic part is composed of a number of chips. At 3–t and 5–t are shown peculiar tissues often found in these coals.

B. A thin cross section of the Sesser coal (×200), showing the angular and irregular resinous-appearing particles common in this coal.

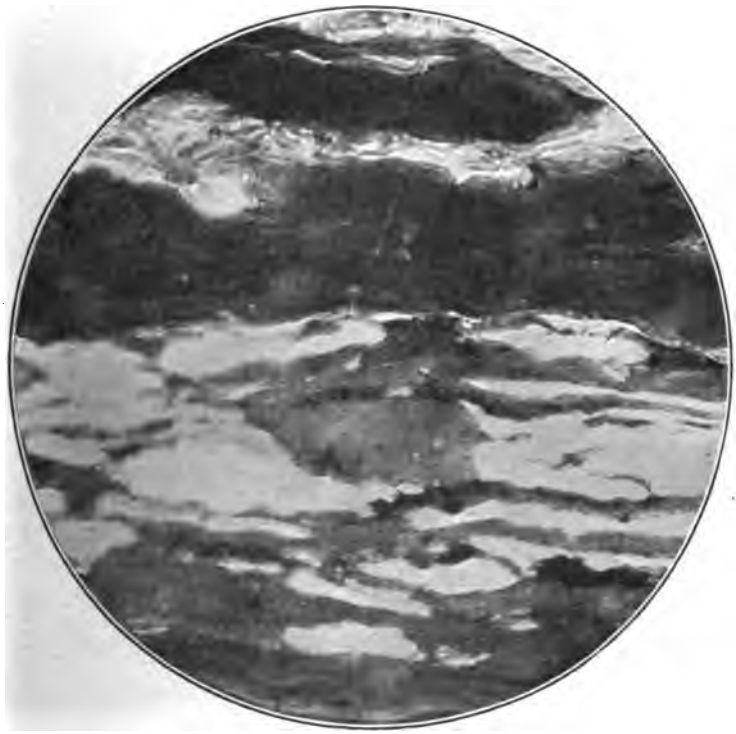
PLATE CIV.

THIN VERTICAL SECTIONS.

A. Another characteristic appearance in cross section of the Sesser coal. (×200.) The humic matter is relatively large and is coarsely disintegrated.

B. A part of the same section shown in *A*. (×1,000.) The thick-walled spore-exines predominant in this coal and found in all the coals of vein No. 6 are shown in cross section, embedded in humic matter.

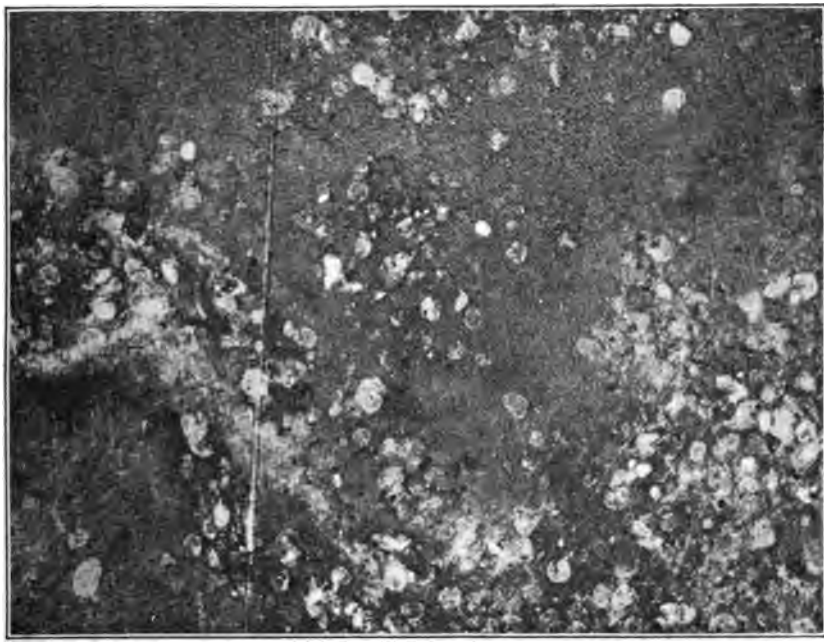
A. THIN VERTICAL LAYER OF ZEIGLER COAL, REPRESENTING A LAYER OF HUMIC ATTRITUS. (X 200)



B. PART OF THE LAMINA 3-D, SHOWN ABOVE. (X 1000)

A. THIN VERTICAL SECTION OF A LAYER OF AN ILLINOIS COAL, SHOWING CUTICLES AND OTHER DEGRADATION PRODUCTS OF LEAVES. (X 200)

B. SECTION OF A LAYER SIMILAR TO THAT ABOVE, SHOWING PAIRS OF CUTICLES CLOSELY UNITED. (X 200)

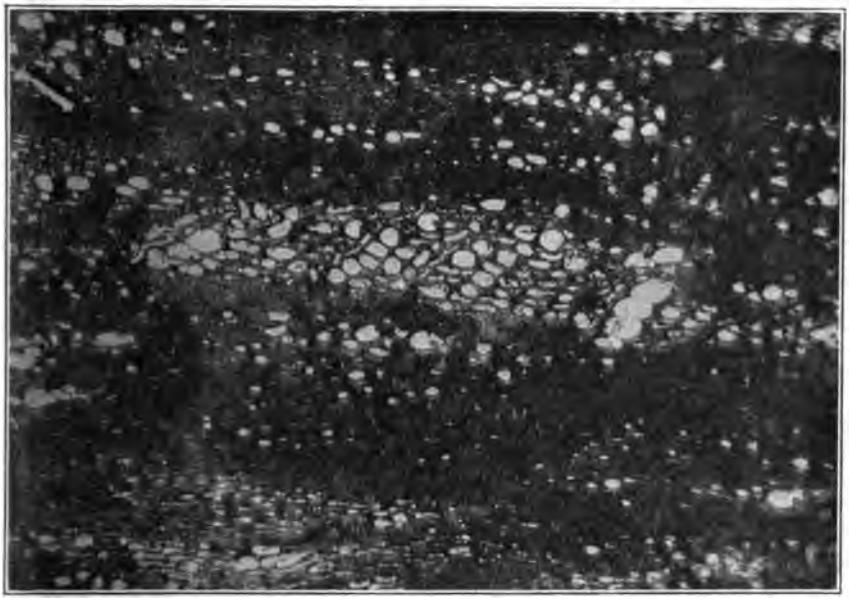


A. THIN HORIZONTAL SECTION SHOWING GENERAL APPEARANCE OF THE ZEIGLER COAL. (X 150)

B. ANOTHER THIN SECTION OF THE ZEIGLER COAL, SHOWS ANTHRAXYLON MATTER. (X 150)

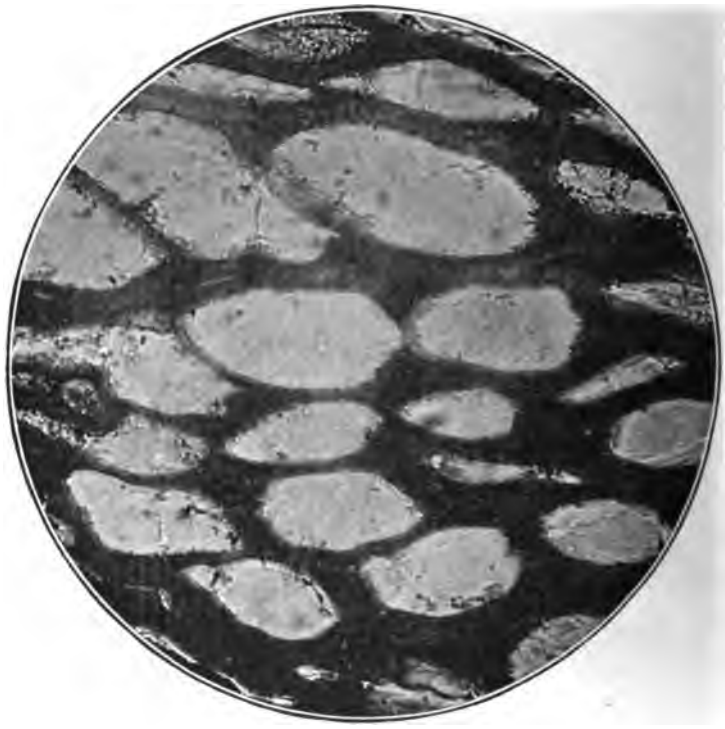
A. THIN VERTICAL SECTION OF THE COAL FROM SESSER, ILL. (X 10)

B. PART OF THE SECTION SHOWN ABOVE. (X 200)



A. THIN CROSS SECTION OF THE "BRIGHT COAL" SHOWN IN PLATE XXIV, *B*. (X 200)

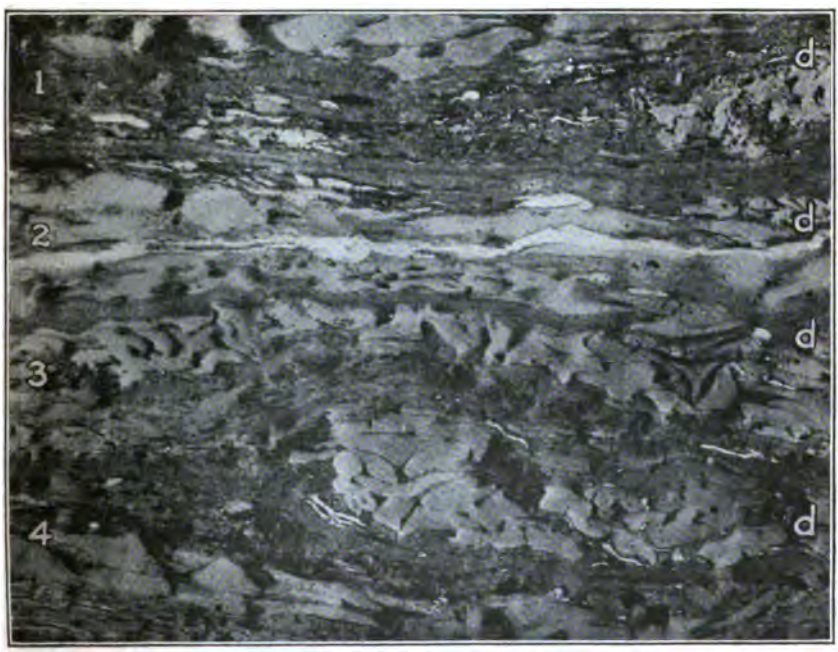
B. PART OF THE SECTION SHOWN ABOVE. (X 1000)



A. ANOTHER PART OF THE SECTION SHOWN IN PLATE CI. *A*. (X 1000)

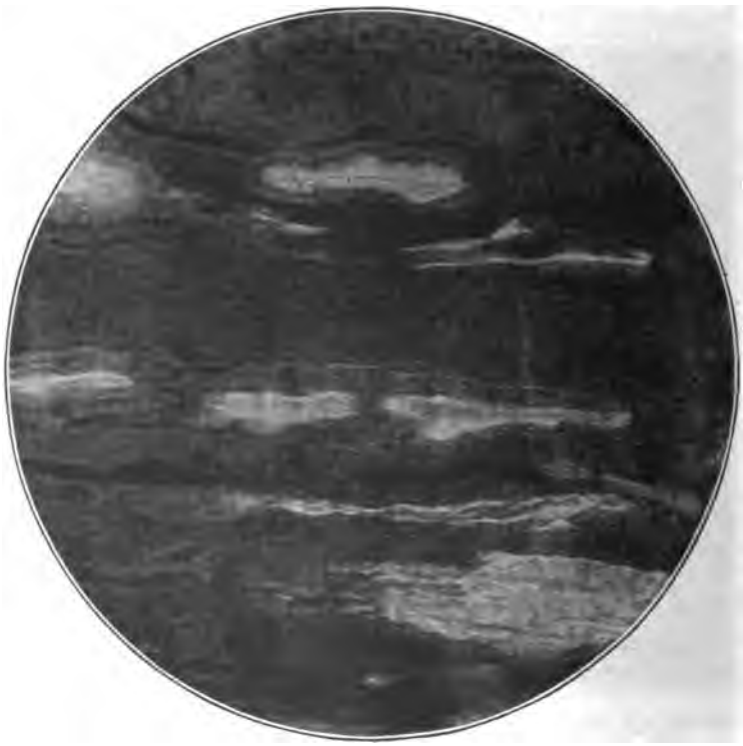
B. THIN VERTICAL SECTION OF ANTHRAXYLON. (X 200)

A. THIN VERTICAL SECTION OF ANTHRAXYLOUS MATERIAL IN COAL FROM SESSER, ILL. (X 200)



B. SECTION OF SESSER COAL, SHOWING RESINOUS-APPEARING PARTICLES. (X 200)

A. THIN CROSS SECTION OF SESSER COAL, SHOWING COARSENESS OF HUMIC MATTER. (X 200)



B. PART OF SECTION SHOWN ABOVE. (X 1000)

PLATE CV.

THIN VERTICAL SECTIONS.

A. A cross section of the Sesser coal (×1,000), showing in detail the appearance of the thick-walled spore-exines characteristic of these coals, other spore-exines, and the humic matter embedding them.

B. A cross section of the Zeigler coal (×1,000) from the section shown in Plate XCIV, *B*, to be compared with *A*, showing the similarity of the constituents, particularly the thick-walled spore-exines.

PLATE CVI.

THIN VERTICAL SECTIONS.

A. A thin cross section (×10), of the Royalton coal, photographed by means of transmitted light, showing, so far as they can be shown in a small section, the structure, the proportion of anthraxylous matter to attritus, and the relative thickness of the anthraxylon chips. The gray striæ are the thin anthraxylon chips and the darker striæ the attritus in which the former are embedded. At 3–d the attritus is rich in carbonaceous matter. At 4–a the anthraxylous matter forms a solid mass, although composed of numerous thin chips.

B. A portion of the section shown in *A* (×200), showing the components in detail. At 1–d is seen a humic-resinous layer; at 2–d, a layer containing humic, resinous, and cuticular matter, including spore-exines; at 3–d are shown numerous thin humic or anthraxylous strips; at 4–a is a tissue, the original cell structure of which is particularly well preserved.

PLATE CVII.

THIN VERTICAL SECTIONS.

A. A thin cross section of "bright coal" or anthraxylon of the Royalton coal (×200), showing the well-preserved wood structure. Such state of preservation is common and the type of tissue is prominent in this coal.

B. A thin section of another anthraxylon component of the same coal. (×200.) The cell-fiber walls seemingly have not lost much of their original mass, but the walls have been pressed together.

PLATE CVIII.

THIN VERTICAL SECTIONS.

A. A thin cross section through the "dull" coal of the Royalton coal (×200), containing a relatively large number of spore-exines, embedded in an attritus at 2–d, rich in carbonaceous matter and at 3–d, rich in humic matter; the anthraxylon matter at 4–a consists of many very thin strips.

B. A part of the section shown in A (×1,000), showing the constituents in detail.

PLATE CIX.

THIN VERTICAL SECTIONS.

A. Another typical view of the "dull coal" of the Royalton coal. (×200.) The attritus is rich in carbonaceous matter. At 2–a are anthraxylon strips separated by dark earthy matter.

B. A portion of the section shown in the central part of *A*. (×1,000.) The original cell structure of the anthraxylon chips is revealed in the striæ seen at a high magnification.

PLATE CX.

THIN VERTICAL SECTIONS.

A. A thin cross section of the Royalton coal (×200), showing the similarity of constituents of this and the Zeigler coal. At 2–d is shown much humic, spore and cuticular matter; at 3–d is shown the irregularly folded cork-like tissue also characteristic of the Zeigler and Benton coals.

B. A part of the section shown in *A* at the level 3–d (×1,000), showing the nature of the light colored tissue in detail.

PLATE CXI.

SPORE-EXINES WITH HEAVY SPINES.

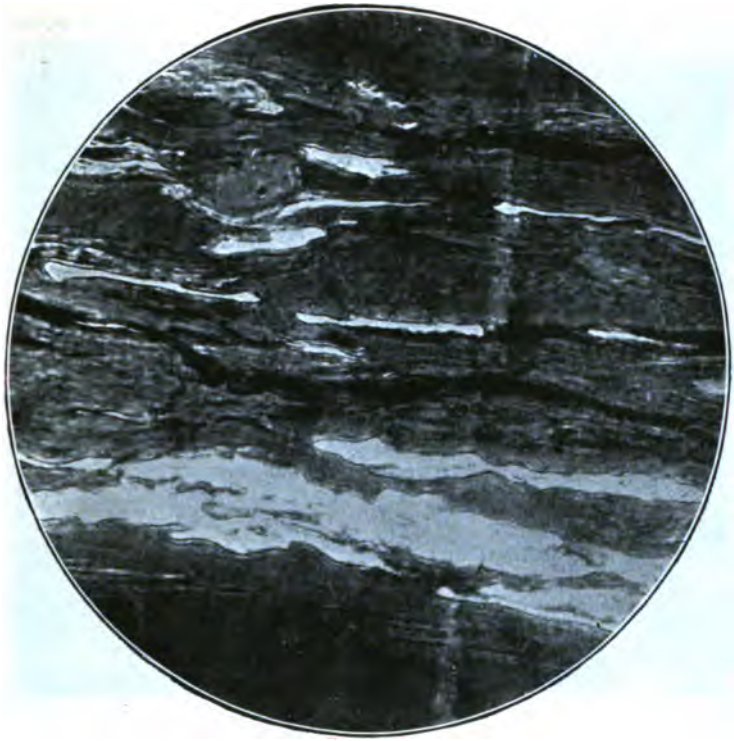
A. A more highly magnified portion of the horizontal section of the coal from Zeigler, Ill., shown in Plate XCIX, *A* (×1,000), showing an attritus rich in carbonaceous matter and a peculiar type of spore-exine embedded in it.

B. A spore-exine (×1,000) isolated from the coal from the Hart-Williams mine, with relatively thick, long, blunt spines, similar to the one shown in *A*

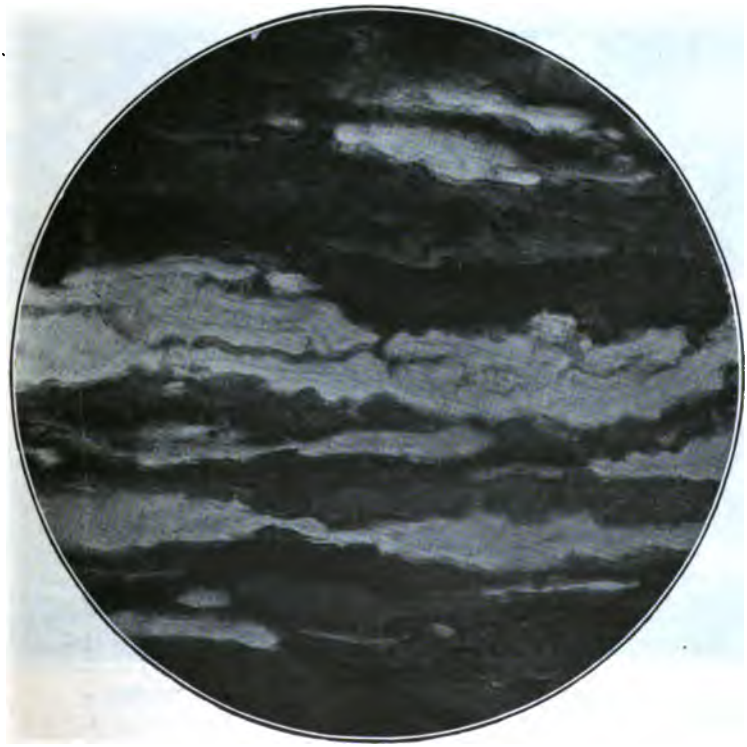
PLATE CXII.

SPORE-EXINES AT HIGH MAGNIFICATIONS.

1. A relatively large spore-exine (×1,000) isolated from the Royalton coal, having a reticulated sculptured surface.
2. A relatively small spore-exine (×1,000) isolated from the coals of vein No. 6. Very minute spines are arranged regularly over the surface.
3. A spore-exine very similar to that shown in photograph 2.
4. A spore (×200) isolated from the Hart-Williams coal, but found in all the coals of this group.
5. Another spore-exine (×200) isolated from the Hart-Williams coal, but also present in the other coals of this group.
6. A spore-exine (×200) isolated from the Royalton coal.
7. A spore-exine (×1,000) isolated from the Sesser coal; it is predominant in the Sesser coal, but is characteristic of the whole group. The exine is shown in cross section in Plate LXXXIX, *B;* Plate XC, *A* and *B;* Plate XCVI, *B;* Plate XCVII, *B;* Plate CIV, *B;* Plate CV, *A* and *B;* and Plate CVIII.



A. THIN CROSS SECTION OF THE SESSER COAL, SHOWING APPEARANCE OF SPORE-EXINES. (X 1000)

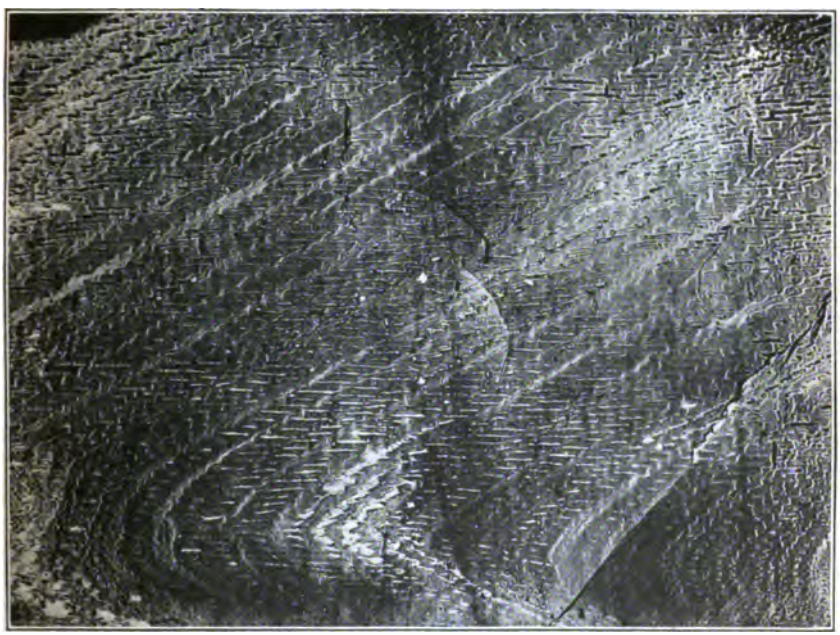


B. THIN CROSS SECTION OF THE ZEIGLER COAL, SHOWING SPORE-EXINES. (X 1000)

A. THIN CROSS SECTION OF COAL FROM ROYALTON, ILL. (X 10)

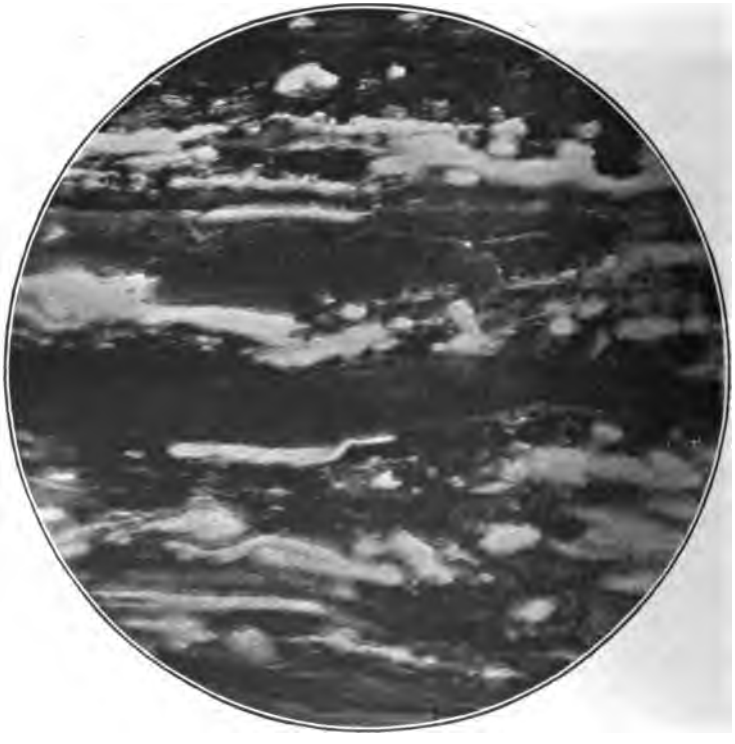
B. PART OF THE SECTION SHOWN ABOVE. (X 200)

A. THIN CROSS SECTION OF THE "BRIGHT COAL" OR ANTHRAXYLON OF THE ROYALTON COAL. (X 200)

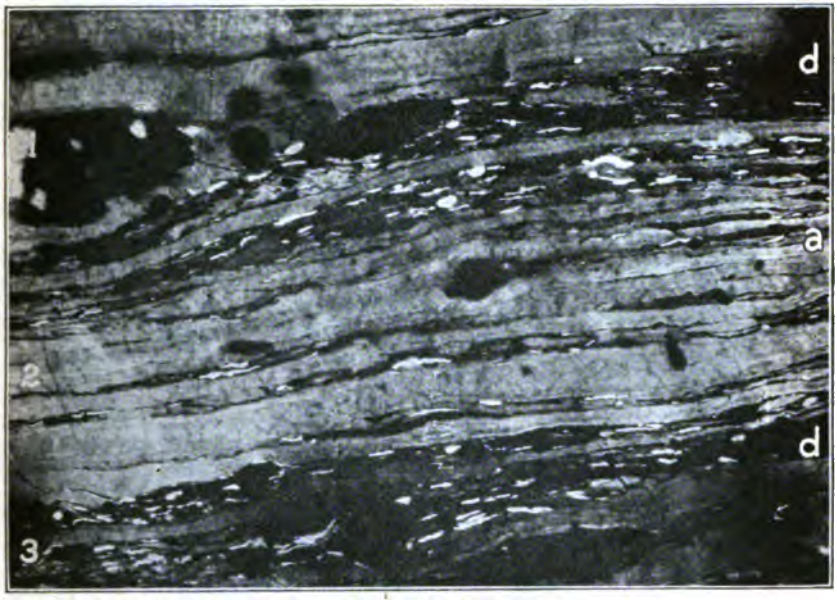


B. CROSS SECTION OF ANOTHER ANTHRAXYLON COMPONENT OF THE ROYALTON COAL. (X 200)

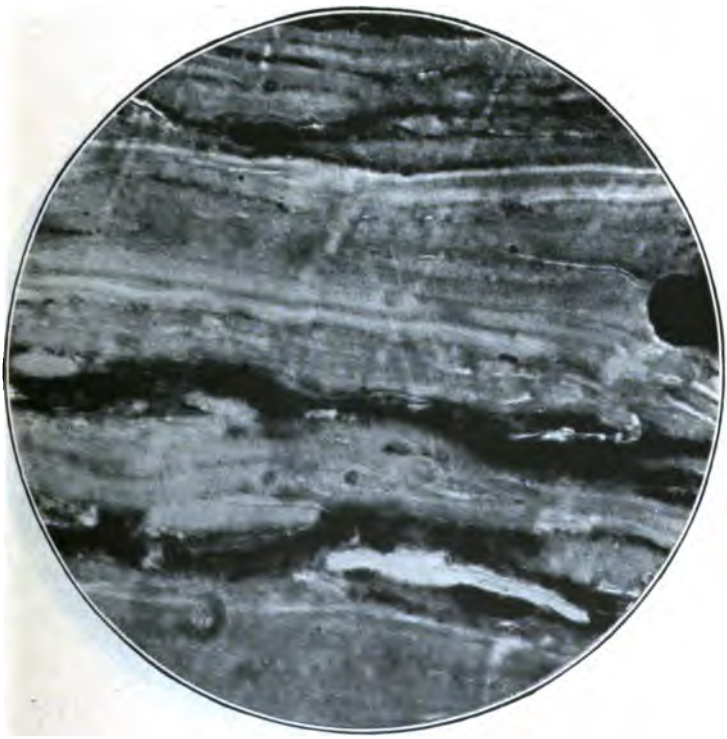
A. THIN VERTICAL SECTION THROUGH THE "DULL COAL" OF THE ROYALTON COAL. (X 200)



B. PART OF THE SECTION SHOWN ABOVE. (X 1000)

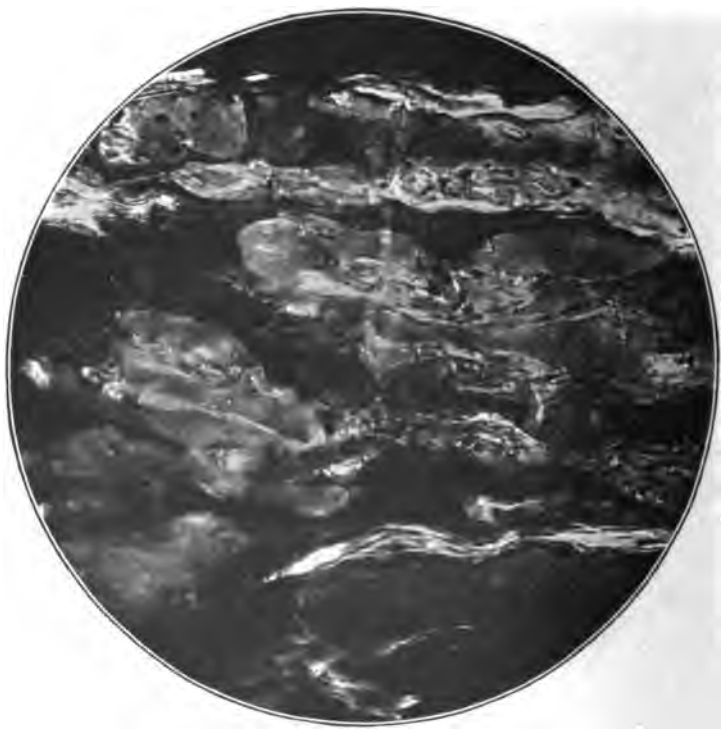


A. ANOTHER TYPICAL CROSS SECTION OF THE "DULL COAL" IN ROYALTON COAL. (X 200)

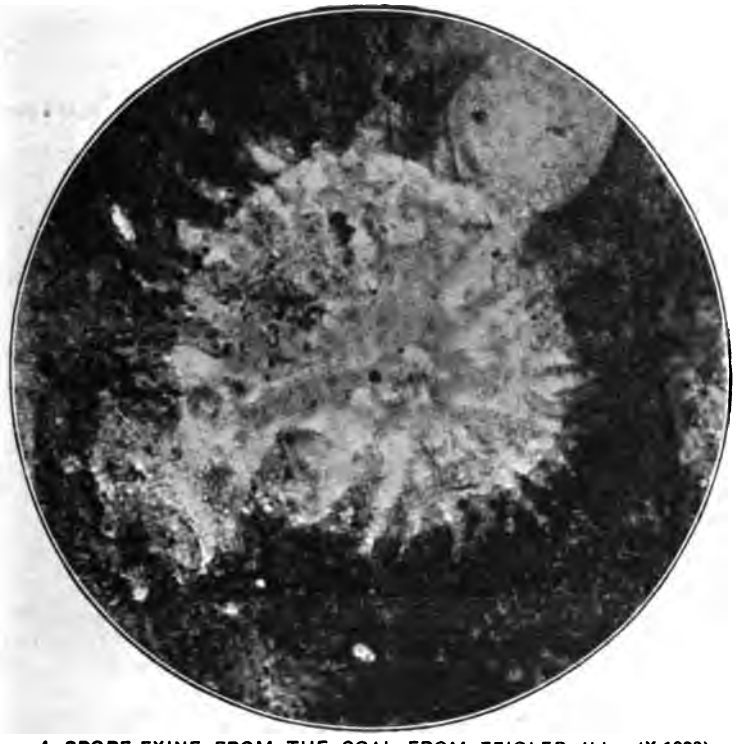


B. PART OF SECTION SHOWN ABOVE. (X 1000)

A. THIN VERTICAL SECTION OF THE ROYALTON COAL, SHOWING SIMILARITY WITH ZEIGLER COAL. (X 200)

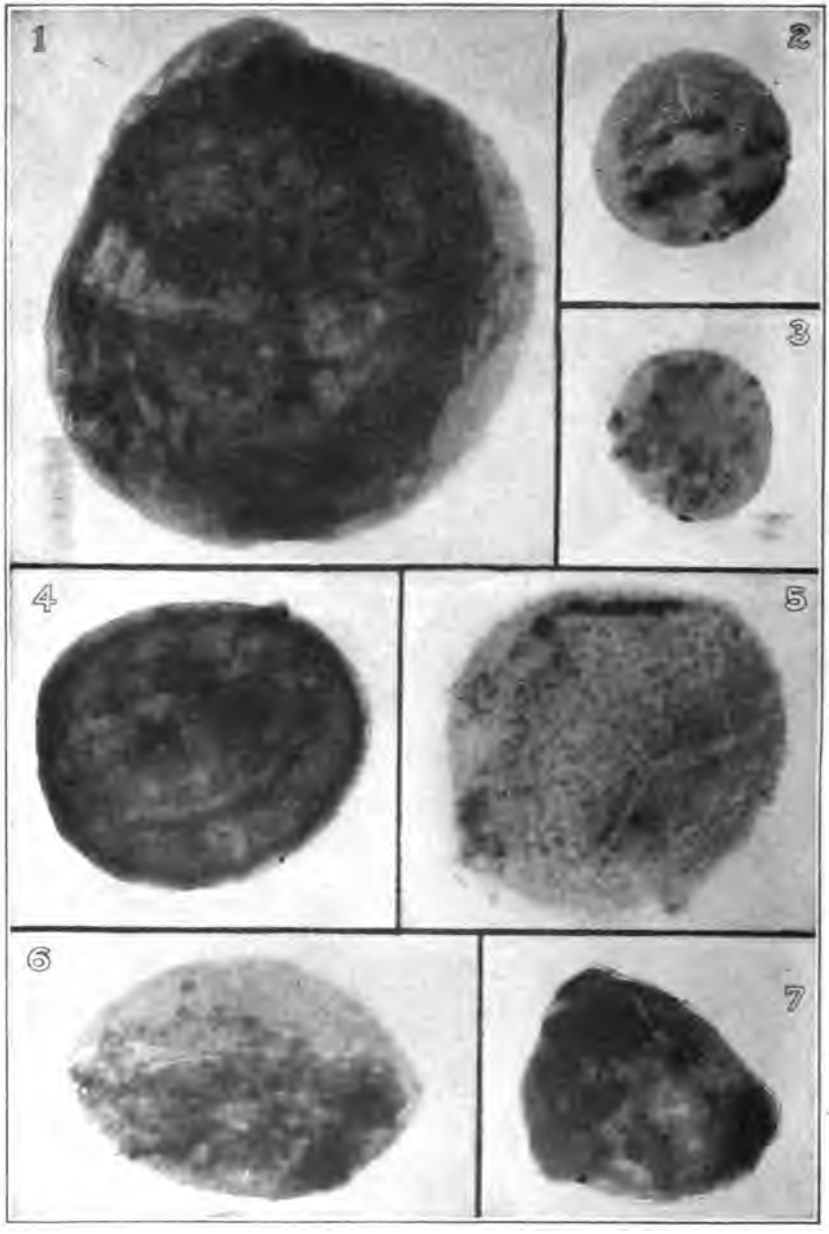


B. PART OF SECTION SHOWN ABOVE. (X 1000)



A. SPORE-EXINE FROM THE COAL FROM ZEIGLER, ILL. (X 1000)

B. SPORE-EXINE FROM THE COAL FROM THE HART-WILLIAMS MINE, NEAR BENTON, ILL. (X 1000)



SPORE-EXINES AT HIGH MAGNIFICATION.

PLATE CXIII.

CUTICLE AND SPORE-EXINE.

A. One of the cuticles abundant in the coal of the No. 6 bed, Illinois. (×100.)

B. The predominant exine of the Shelbyville coal (×1,000) shown on its flat or broad side and isolated. The dark area in the centre represents the spore proper; the broad zone surrounding it perhaps functioned as a wing.

PLATE CXIV.

THIN VERTICAL SECTIONS.

A. A thin cross section of the coal from Shelbyville, Ill. (×200), showing a part of a thicker anthraxylon component of the type of tissue found in all the coals examined. This tissue is similar to that in the annual growth rings of recent trees. See also Plate CI, *A* and *B;* Plate CII, *A;* and Plate LIX.

B. A more highly magnified portion of the tissue shown in *A.* (×1,000.) The resinous matter is present in most of the thin-walled cells and is absent or almost absent in the thick-walled cells.

PLATE CXV.

THIN VERTICAL SECTIONS.

A. A thin cross section (×200) showing the general appearance of the "dull coal," of the coal from Shelbyville, Ill. The band at 2–r has a resinous appearance and is common in this coal. Small anthraxylon strips are seen at 3–d to 4–d.

B. A part of the section shown in *A.* (×1,000.) Note the appearance of the spore-exines in cross section.

PLATE CXVI.

THIN VERTICAL SECTIONS.

A. Part of another typical cross section of the Shelbyville coal, showing many relatively large spore-exines, much disintegrated humic matter, and some humic or anthraxylon matter in strips.

B. A part of the section shown in *A* (×1,000), showing the constituents in detail.

PLATE CXVII.

SPORE-EXINES AND POLLEN GRAIN FROM THE SHELBYVILLE COAL.

1. An isolated spore-exine (×200) from the Shelbyville coal. Various authors have mentioned a spore much like this, as that of a Spencerite. The outer band represents a wing of the spore and the inner area the spore proper. Small numbers of this spore have been found in all the coals examined.

2. A smaller type of spore-exine (×1,000), predominant in the Shelbyville coal.

3. A pollen grain (×1,000) isolated from the Shelbyville coal, of the same type as found in all the coals examined.

PLATE CXVIII.

MEGASPORE-EXINES FROM THE SHELBYVILLE COAL.

A. One of the larger megaspore-exines (×35) isolated from the Shelbyville coal. These spore-exines measure 2 to 3 mm. across the disk in their flattened condition. They are predominant in the Shelbyville coal, but are also found in large numbers in the Buxton coal and occasionally in the Pittsburgh coal.

B. A number of the smaller megaspore-exines (×35) common in the Shelbyville coal. These spores have three blunt wings or air sacks, represented by the tongue-like processes. Compare these spores with those from the Buxton coal shown in Plate CXXX, *A* and *B*, and Plate CXXXI, 1 to 4.

PLATE CXIX.

MEGASPORE-EXINES.

A. A group of three megaspore-exines (×35) of the same type as shown in Plate CXVIII, *A*, isolated from the coal.

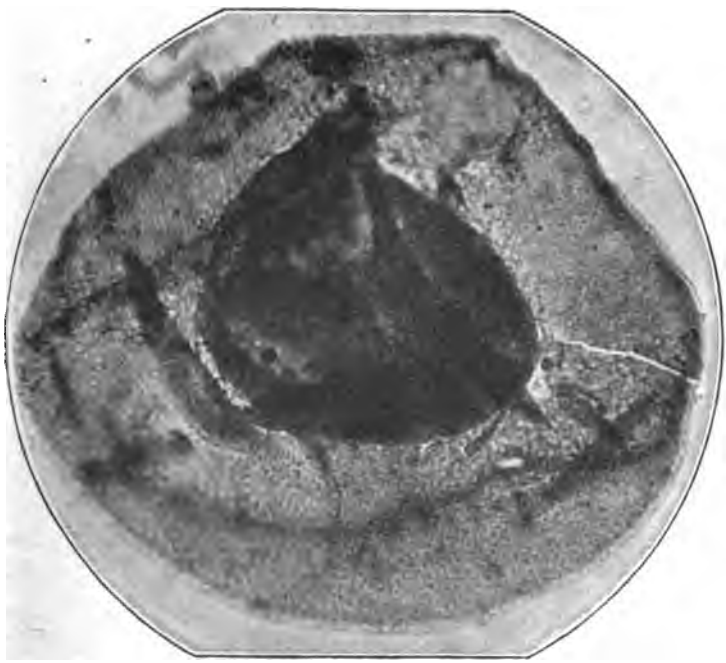
B. A thin cross section (×35) of the Shelbyville coal showing the same type of megaspore-exine, in cross section, in situ. Note the relative thickness and the blunt air sacks or appendages.

PLATE CXX.

LEAF TISSUES FROM THE SHELBYVILLE COAL.

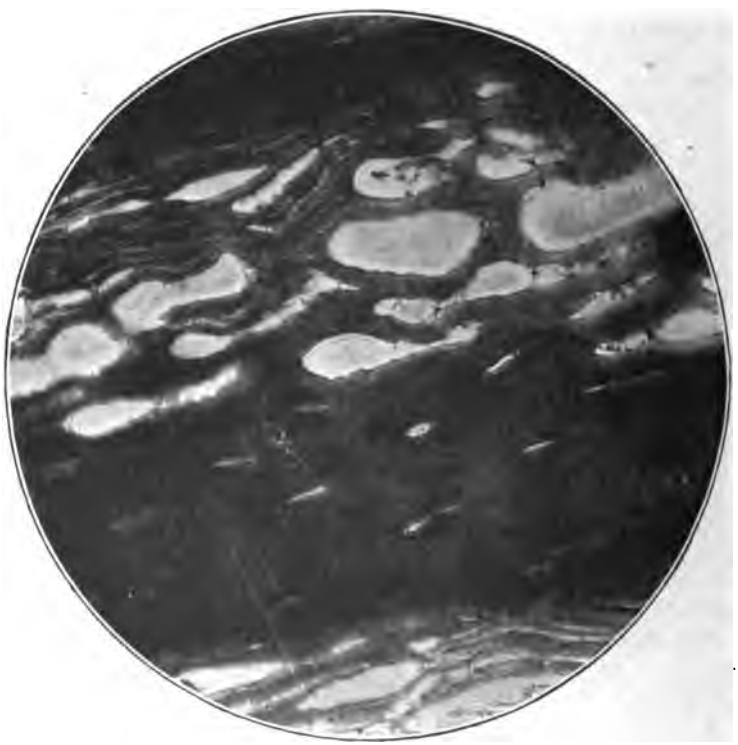
Thin cross section of Shelbyville coal containing leaf tissues. 1–c, a mass of closely packed cuticles; 2–a to 3–pl, part of a leaf; 4–c to 9–c, part of another leaf; 2–pa, leaf parenchyma; 3–pl, palisade cells; 4–c, upper cuticle; 5–h, hypodermal tissue; 6–p, palisade cells; 7–pa, leaf parenchyma; 8–s, lower hypoderman tissue containing stomata; 9–c, lower cuticle (compare with Pl. IX, *A*); 10–d, anthraxylous débris.

A. CUTICLE FROM THE ILLINOIS COAL. (X 100)



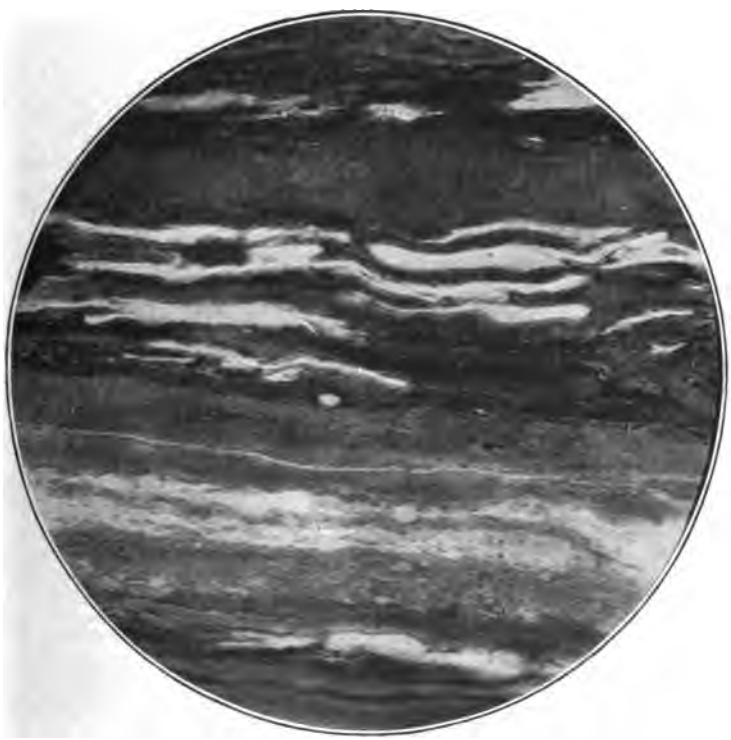
B. SPORE-EXINE IN COAL FROM SHELBYVILLE, ILL. (X 1000)

A. THIN VERTICAL SECTION OF COAL FROM SHELBYVILLE, ILL. (X 200)

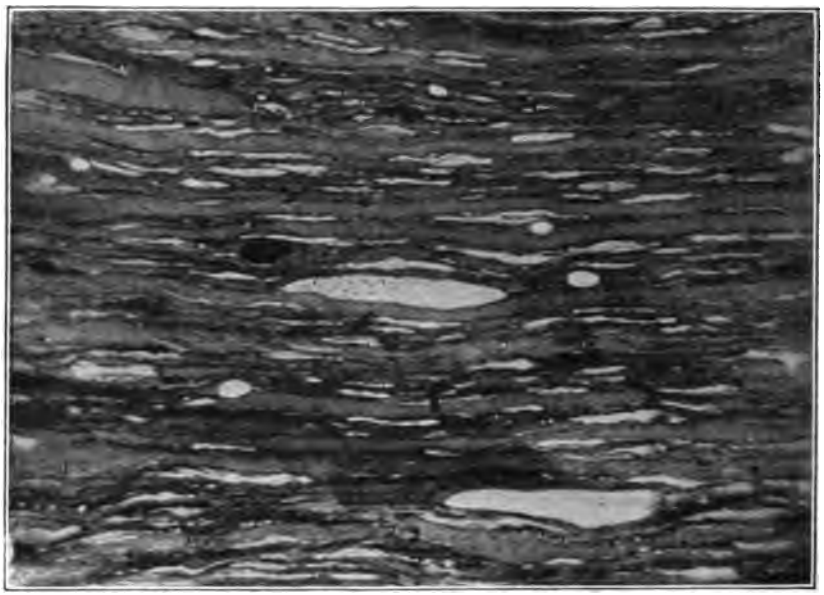


B. PART OF SECTION SHOWN ABOVE. (X 1000)

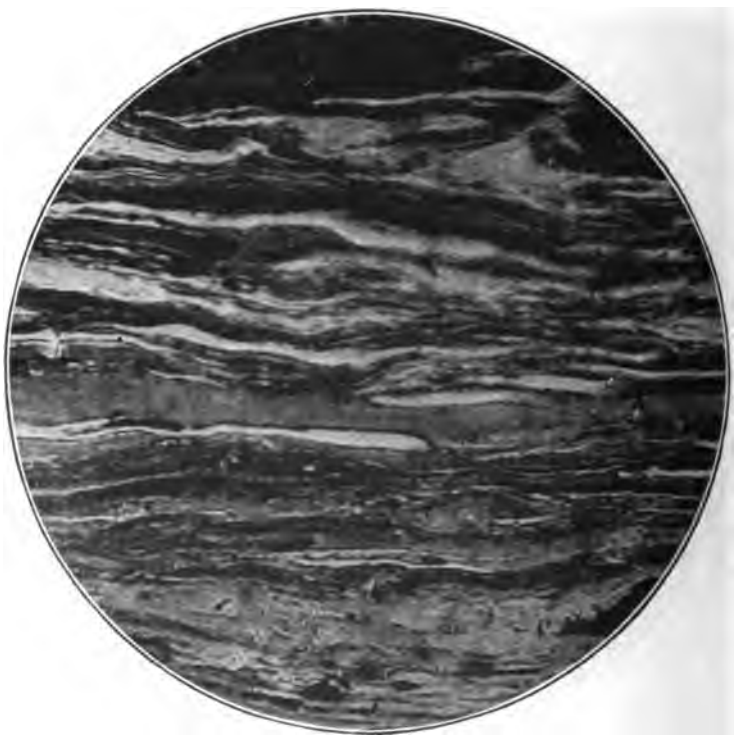
A. THIN VERTICAL SECTION SHOWING GENERAL APPEARANCE OF THE "DULL COAL" IN COAL FROM SHELBYVILLE, ILL. (X 200)



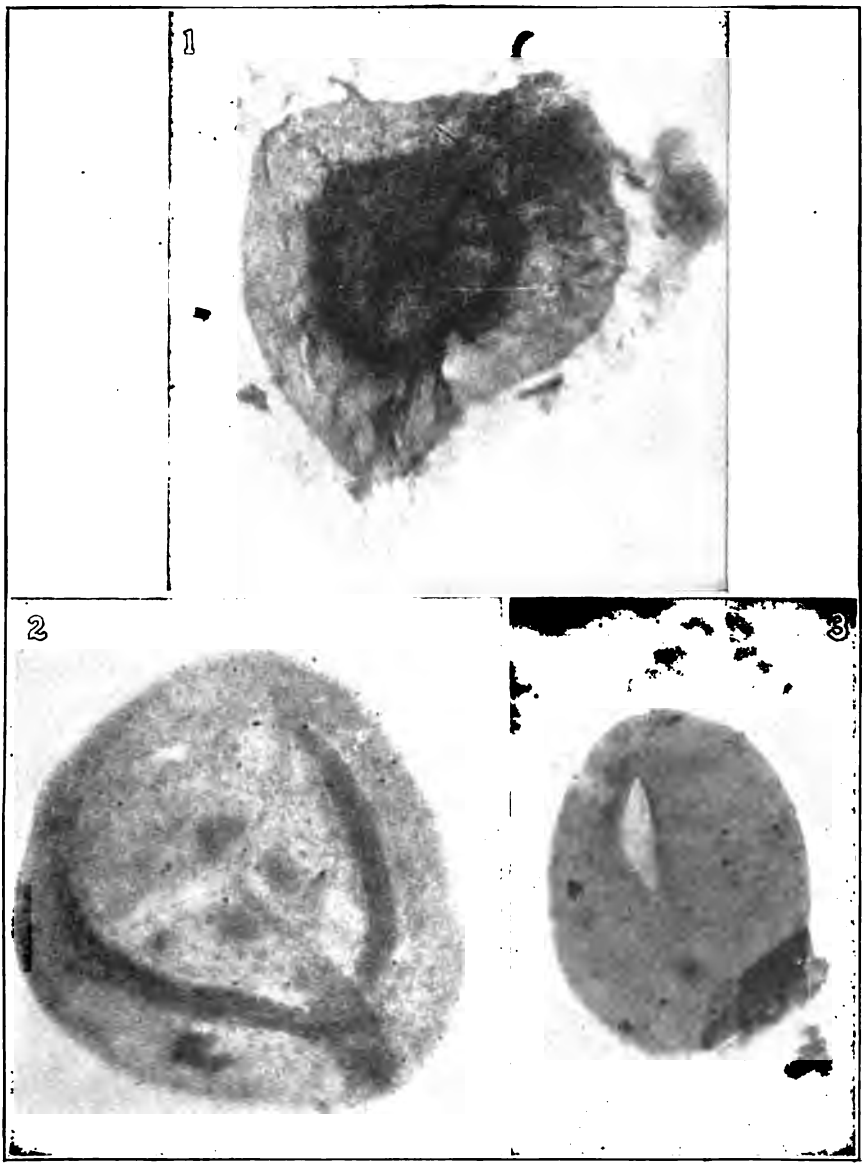
B. PART OF ABOVE SECTION. (X 1000)



A. ANOTHER TYPICAL CROSS SECTION OF THE SHELBYVILLE COAL. (X 200)



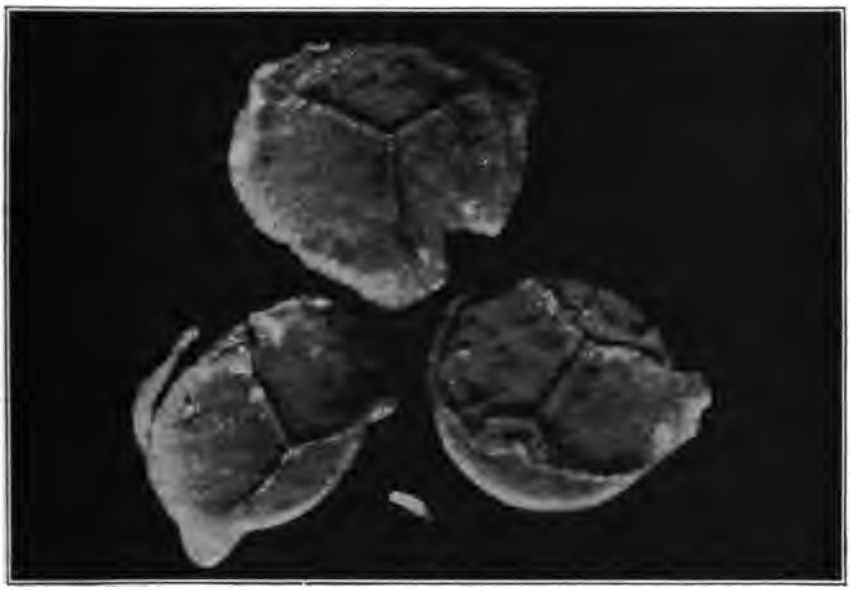
B. PART OF THE SECTION SHOWN ABOVE. (X 1000)



SPORE-EXINES FROM THE COAL FROM SHELBYVILLE, ILL.

A. MEGASPORE-EXINE IN THE COAL FROM SHELBYVILLE, ILL. (X 35)

B. SOME OF THE SMALLER MEGASPORE-EXINES IN THE SHELBYVILLE COAL. (X 35)



A. THREE MEGASPORE-EXINES ISOLATED FROM COAL FROM SHELBYVILLE, ILL. (X 35)

B. CROSS SECTION OF COAL FROM SHELBYVILLE, ILL. (X 35), SHOWING MEGASPORE-EXINES IN SITU.

LEAF TISSUES IN COAL FROM SHELBYVILLE, ILL.

PLATE CXXI.

THIN AND THICK VERTICAL SECTIONS.

A. A cross section of the coal from Buxton, Iowa, showing the general lamination of the coal, ratio of constituents and general appearance at a low magnification (×10), photographed by means of transmitted light. The lamina at 1–d is attritus in which are lodged thin anthraxylon strips. The lenticular white areas, 2–s, represent masses of intimately united and closely packed spore-exines, the remnants of sporangia filled with spores, embedded in the attritus. (See Pls. CXXXIII and CXXXIV.) The strip at 3–a is anthraxylon partly split. The lamina at 4–d represents attritus rich in spore-exines in which are also a number of megaspore-exines and a thick cuticle, 5–c; at 6–d is a carbonaceous inclusion, and at 7–a (see *B*) is part of a thicker anthraxylon component.

B. The mirror image of *A*, prepared by means of reflected light from the same surface before it was ground into a thin section. The features and the lettering are the same.

PLATE CXXII.

THICK VERTICAL SECTION AND HORIZONTAL CLEAVAGE SURFACE.

A. An opaque surface from the Buxton coal (×10) photographed by means of reflected light. The dark strip 1–a, is anthraxylon; below this is a "dull coal," consisting at 2–d of some humic matter, some megaspore-exines, a few leaf cuticles, and a considerable amount of carbonaceous matter, but chiefly of spore-exines. At 3–d are embedded large carbonaceous particles; at 4–d are sporangia and a large proportion of carbonaceous matter, some cuticles, humic matter, and spore-exines; at 5–d is a carbonaceous débris containing fine chips of anthraxylous matter.

B. Horizontal cleavage surface of a small block of the Buxton coal, showing the woody patches, structureless areas and the general appearance of the cleavage surface of the coal. The two woody patches in the upper part represent bits of charcoal.

PLATE CXXIII.

HORIZONTAL CLEAVAGE SURFACE.

Part of a horizontal cleavage surface (×5) of Buxton coal containing a large number of woody patches. Although the decay of woody matter seems to have been far advanced before coalification, the wood fibers are still distinct. These woody patches represent, as in other coals, thin anthraxylon components and are not merely impressions.

PLATE CXXIV.

THIN VERTICAL SECTIONS.

A. A thin cross section (×200) of the Buxton coal, showing the general nature and appearance at a high magnification. At 4–c is a cuticle, common in this coal. The dull coal consists of irregular anthraxylon chips, shown as gray fibrous strips, and of disintegrated and finely-divided humic matter, relatively few spore-exines, some carbonaceous matter, earthy matter, and iron pyrite nodules.

B. A thin cross section (×200) typical of the Buxton coal. 1–a represents a common appearance of the anthraxylon; the attritus at 2–d is rich in carbonaceous and earthy matter, including spore-exines as well as some resinous matter; the tissue at 3–sp is frequently found in this coal and represents a part of a sporangium, similar structures are found in other coals. Compare with Plate LX of the Pittsburgh seam, and Plate CXXXIII, *A* and *B*.

PLATE CXXV.

THIN VERTICAL SECTIONS.

A. A thin cross section of the Buxton coal (×200), representing a resinous-carbonaceous attritus containing some humic and spore matter.

B. A thin cross section of the Buxton coal (×200), showing another appearance characteristic of this coal. 1–d is a lamina of attritus rich in carbonaceous matter; 2–a is a thin strip of anthraxylon; 3–d is humic attritus rich in earthy and carbonaceous matter, 4–d is particularly rich in such matter; 5–a represents a strip of anthraxylon with characteristic resinous inclusions.

PLATE CXXVI.

THIN VERTICAL SECTIONS.

A. A thin cross section of the Buxton coal (×200), showing compilation of thin irregular anthraxylon strips. At 1–a is part of a large anthraxylon component.

B. A thin cross section of the Buxton coal (×200), showing a lamina with characteristic sheets of resinous matter at 2–d and 5–d. The irregular black blotches represent pyrite granules, such as are scattered throughout this coal.

PLATE CXXVII.

THIN VERTICAL SECTIONS.

A. A thin cross section of the Buxton coal (×200) shows a lamina rich in spore-exines, earthy matter, and carbonaceous matter and containing very little humic matter. The area shown is just below the sporangium shown in Plates CXXXIII and CXXXIV.

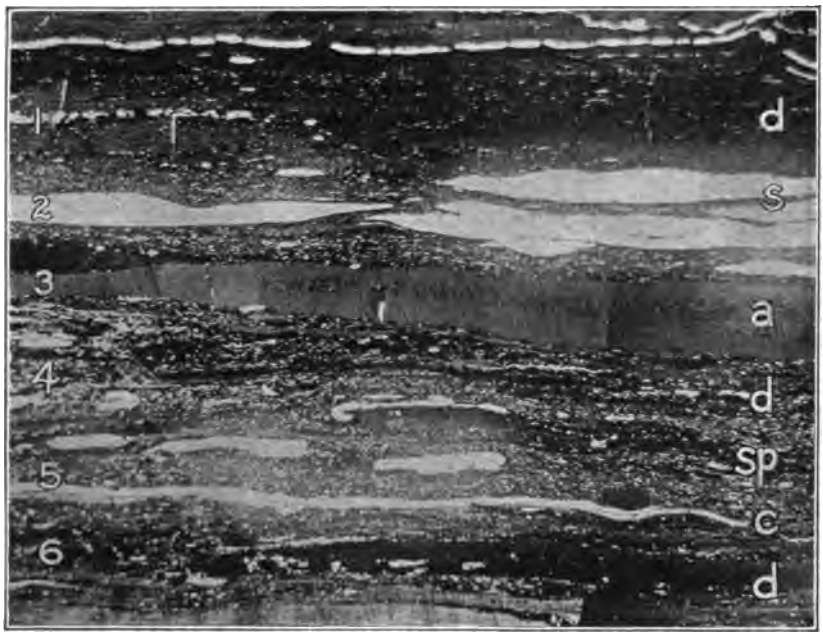
B. A part of the section in *A* (×1,000), showing the spore-exines in detail in cross section. The carbonaceous matter was too opaque to be brought out in detail. The humic matter is shown in gray.

PLATE CXXVIII.

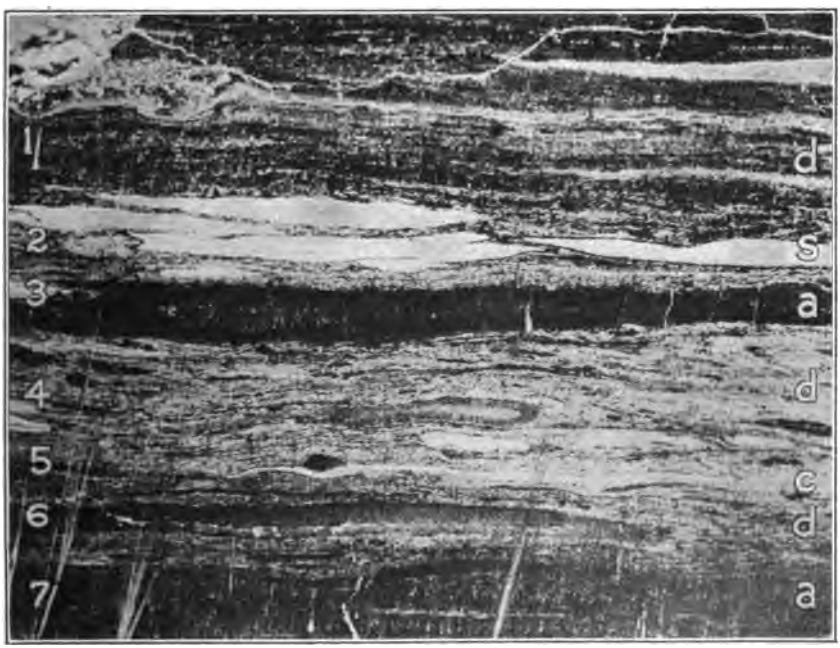
THIN HORIZONTAL SECTIONS.

A. General appearance of the Buxton coal in horizontal section. (×200.) The larger part of the photograph represents a thin slice of an anthraxylon chip, with relatively large, poorly preserved cells.

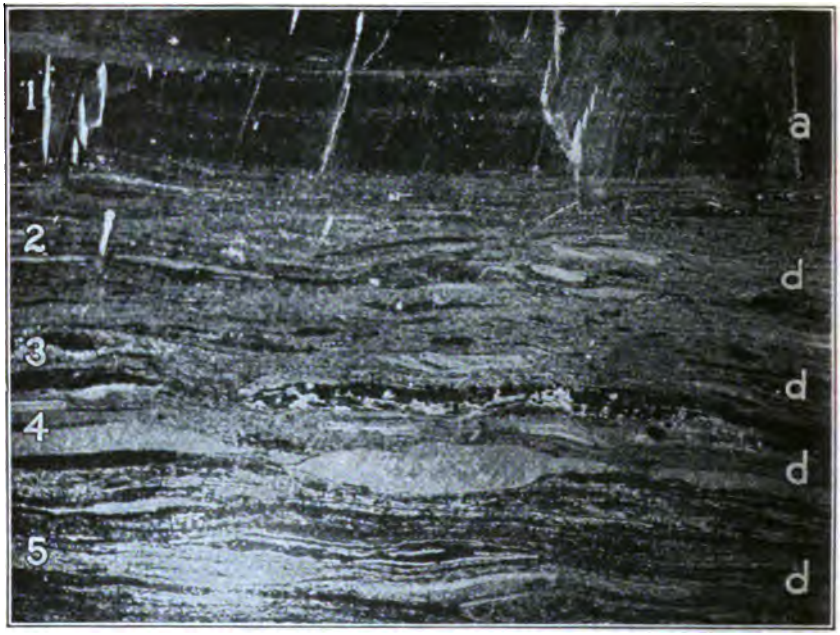
B. Another thin horizontal section (×200), showing humic matter in the lower part containing relatively slender wood fibers, and attritus in the upper part composed of humic matter, spore-exines, carbonaceous matter, and iron-pyrite granules.



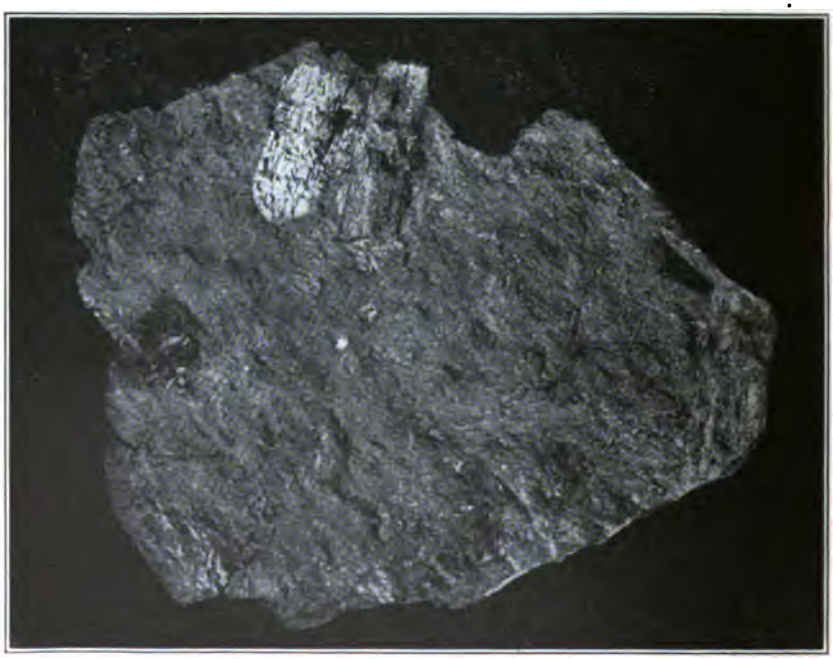
A. THIN VERTICAL SECTION OF THE COAL FROM BUXTON, IOWA. (X 10)



B. THICK VERTICAL SECTION OF THE SAME PIECE OF COAL SHOWN ABOVE. (X 10)

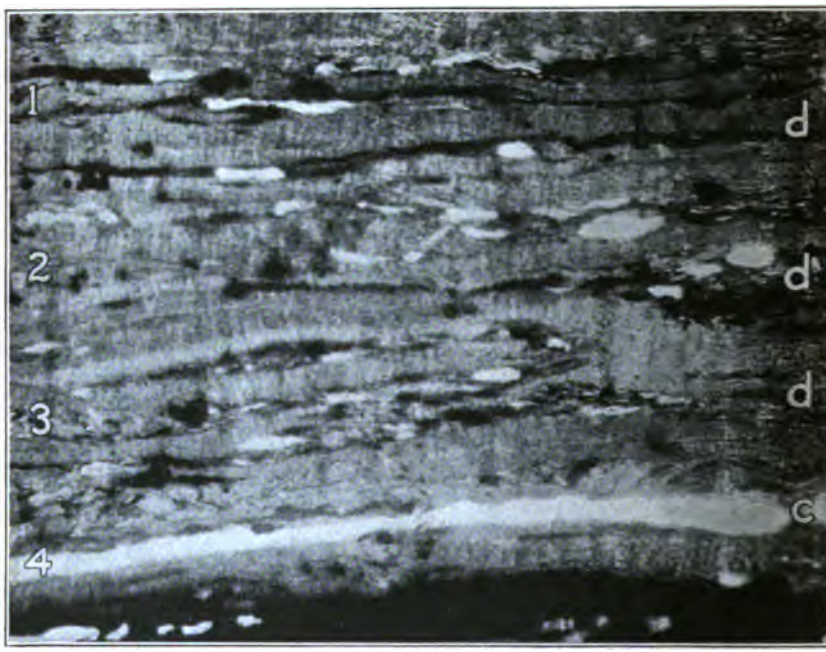


A. THICK VERTICAL SECTION OF COAL FROM BUXTON, IOWA, LOW MAGNIFICATION. (X 10)



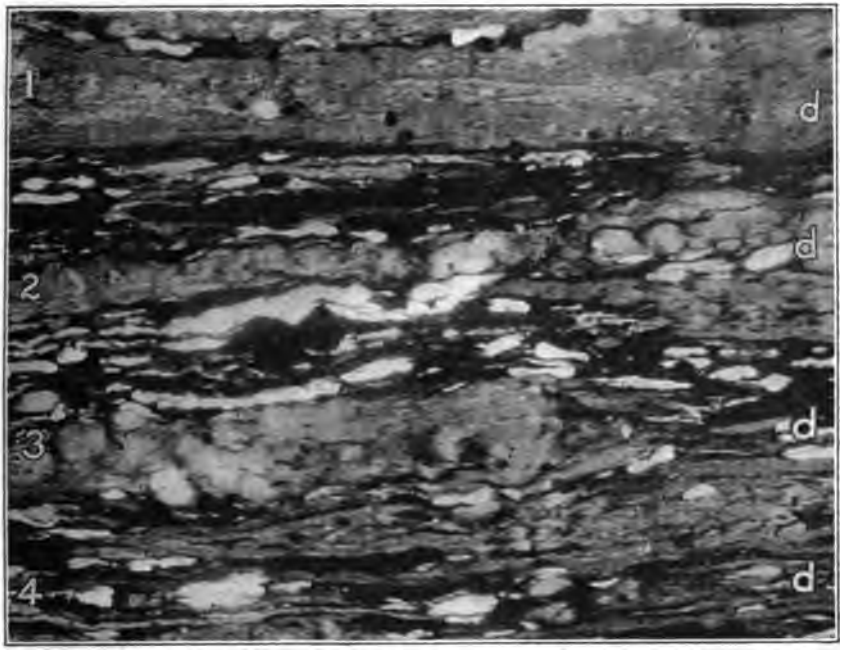
B. HORIZONTAL CLEAVAGE SURFACE OF COAL FROM BUXTON, IOWA.

HORIZONTAL CLEAVAGE SURFACE OF ANTHRAXYLON. (X 5)



A. THIN VERTICAL SECTION OF THE COAL FROM BUXTON, IOWA (X 200), SHOWING GENERAL APPEARANCE AT HIGH MAGNIFICATION.

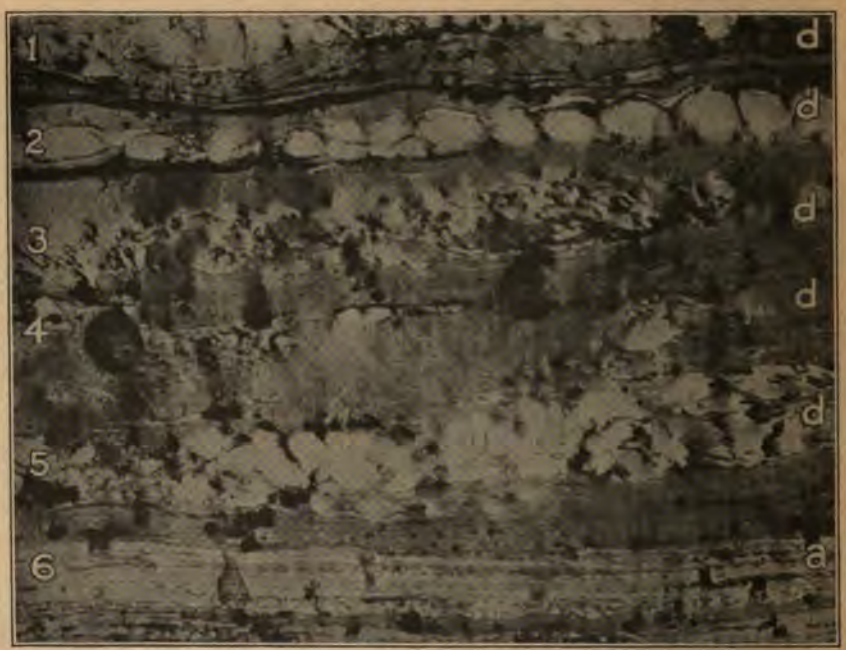
B. THIN VERTICAL SECTION, TYPICAL OF THE BUXTON COAL. (X 200)



A. THIN VERTICAL SECTION OF THE COAL FROM BUXTON, IOWA (X 200), SHOWING APPEARANCE OF RESINOUS-CARBONACEOUS ATTRITUS.

B. THIN VERTICAL SECTION OF THE COAL FROM BUXTON, IOWA (X 200), SHOWING CHARACTERISTIC LAMINATIONS.

A. THIN VERTICAL SECTION OF THE COAL FROM BUXTON, IOWA (X 200), SHOWING IRREGULAR ANTHRAXYLON LAMINATIONS.



B. THIN VERTICAL SECTION OF THE COAL FROM BUXTON, IOWA (X 200), SHOWING RESINOUS SHEETS AND PYRITE GRANULES.

A. THIN VERTICAL SECTION OF COAL FROM BUXTON, IOWA (X 200), SHOWING SPORE-EXINES AND EARTHY AND CARBONACEOUS MATTER.

B. PART OF SECTION SHOWN ABOVE. (X 1000)

A. THIN HORIZONTAL SECTION OF COAL FROM BUXTON, IOWA (X 200), REPRESENTING MOSTLY ANTHRAXYLON.

B. THIN HORIZONTAL SECTION OF THE COAL FROM BUXTON, IOWA (X 200), SHOWING HUMIC MATTER AND ATTRITUS.

PLATE CXXIX.

THIN HORIZONTAL SECTIONS.

A. A thin horizontal section of the Buxton coal (×200) showing attritus composed of pollen grains, spore-exines, humic matter, and carbonaceous matter.

B. A part of the area of the horizontal section shown in *A* (×1,000), showing the constituents in detail, and the granular loose structure of the matrix.

PLATE CXXX.

MEGASPORE-EXINES WITH AIR SACKS.

A. Isolated megaspores (×35) of the smaller type found in the Buxton coal. The lips or tongues represent what is left of large air sacks. The same spores are seen in cross section in Plate CXXXI, 1 to 4. Compare with the spores from the Shelbyville coal, Plate CXVIII, *B*, and Plate CXIX, *A* and *B*.

B. Isolated megaspores (×35) as shown in *A*. The tongues of the one in the upper right-hand corner appear about half of the length they had when embedded in the coal, having been broken during the removal of the spore from the coal.

PLATE CXXXI.

CROSS SECTIONS OF MEGASPORES WITH AIR SACKS.

Cross sections of several of the megaspore-exines (×40) of the type shown in Plate CXXX, *A* and *B*, still embedded in the coal. The cross section of one of the air sacks or wings is well shown in 2.

PLATE CXXXII.

SPORES COVERED WITH RAMENTA.

1. Cross section of a spore-exine of another type (×40) in the Buxton coal. This exine is covered with ramenta now flattened horizontally.
2. Left end portion of the same exine. (×200.)
3. Right end of the same exine. (×200.)
4. End of another spore-exine of the same type. (×200.)

PLATE CXXXIII.

SPORANGIUM.

A. A part of one of the sporangia (×200) shown in Plate CXXI, *A* and *B*, of the Buxton coal. On the left side is the attritus, and on the right side a small portion of the sporangium inclosing spores, sp. The sporangium wall, w, juts into the attritus; on the outside of the sporangium wall is the cuticle, c, covering it; on the inside is a mass of spores in white, sp. not well differentiated, but shown in detail in Plate CXXXIV, *B*. In several photographs parts of tissue have been shown similar to the part of the sporangium wall jutting into the attritus in the lower left part of the photograph; as in Plate CXXIV, *B*, of the Buxton coal and Plate LX, *A*, of the Pittsburgh coal.

B. Another portion of the sporangium, shown also in Plate CXXI, *A* and *B* (×200); the spores are shown at 1–sp; the sporangium wall, at 2–w; and the attritus, at 3–d. The cuticle, c, covering the wall is faintly seen here.

PLATE CXXXIV.

WALL OF SPORANGIUM SHOWN IN PLATE CXXXIII.

A. Part of the sporangium wall, w, of the sporangium shown in Plate CXXXIII, *A*. (×1,000.) The white portion sp is the mass of spores much overexposed, but shown in detail in *B*. The cuticle, c, surrounding the sporangium wall, w, is clearly shown; d is the attritus.

B. The spore-exine mass (×1,000) included in the sporangium wall shown in *A*. The attritus containing the same type of spore-exines is shown in Plate CXXVII, *A* and *B*.

PLATE CXXXV.

SPORES PARTLY COVERED WITH RAMENTA.

1–6. Thin cross sections, showing various views of a type of spore found frequently in the Buxton coals and also in the coals of No. 6 bed, Illinois. This spore has a tuft of ramenta attached, now much disarranged and shortened.

PLATE CXXXVI.

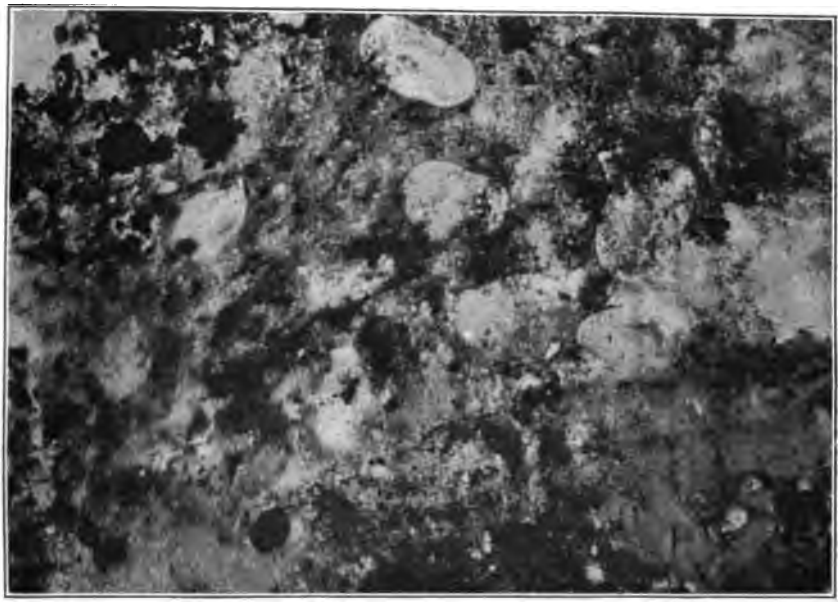
SPORE-EXINES, POLLEN GRAIN, AND CUTICLE.

1. An isolated spore-exine of the type predominating in the Buxton coal. (×1,000.)

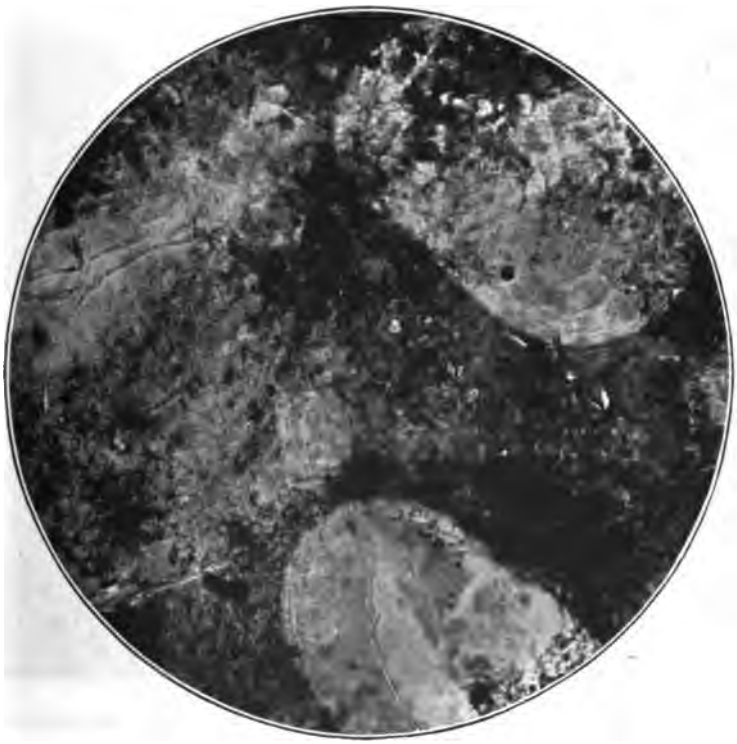
2. Isolated pollen grain found in large numbers in the Buxton coal.

3 and 4. Two other types of spore-exines (×1,000) found in the Buxton coal.

5. One of the cuticles of the Buxton coal.



A. THIN HORIZONTAL SECTION OF THE BUXTON COAL (X 200), SHOWING ATTRITUS.

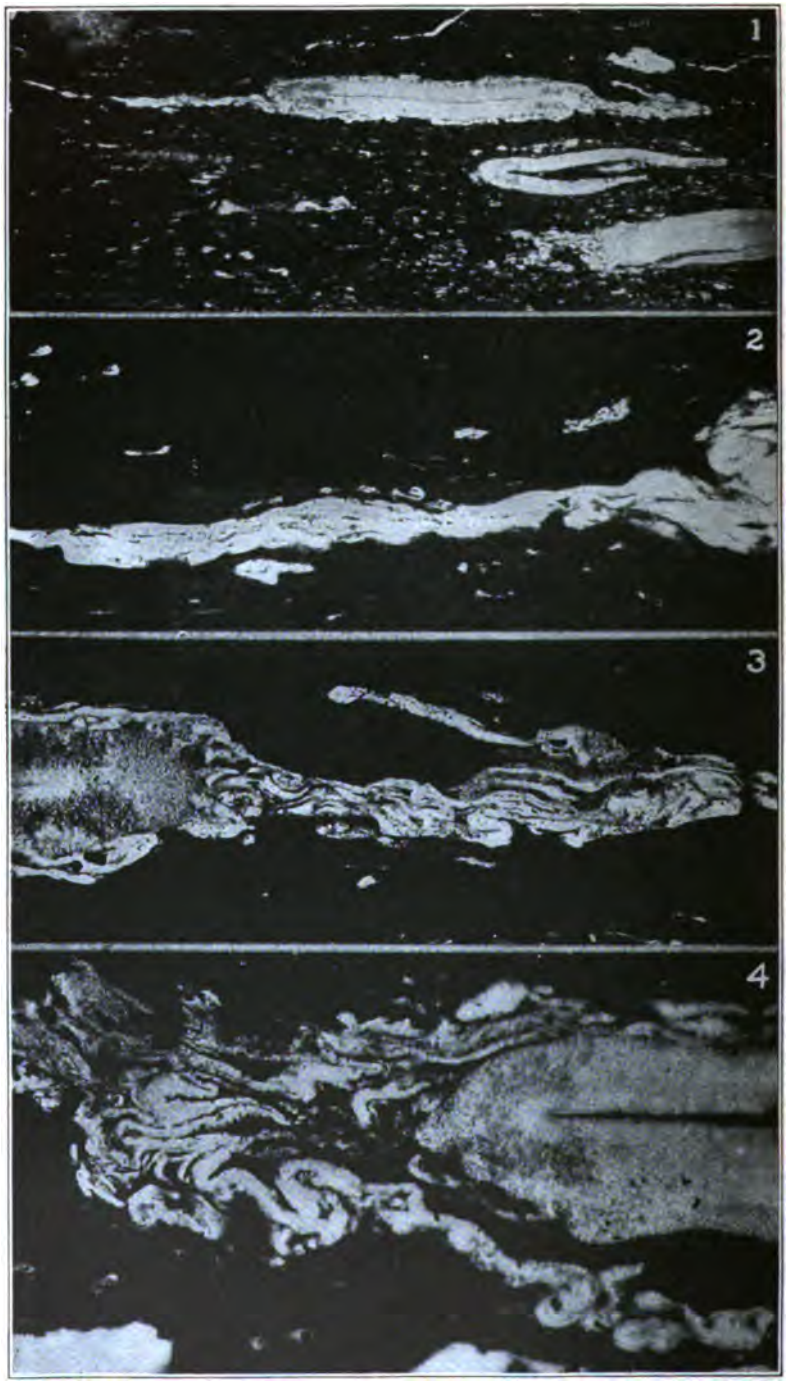


B. PART OF THE SECTION SHOWN ABOVE. (X 1000)

A. MEGASPORE-EXINES ISOLATED FROM THE COAL FROM BUXTON, IOWA. (X 35)

B. ANOTHER GROUP OF MEGASPORE-EXINES ISOLATED FROM THE COAL FROM BUXTON, IOWA. (X 35)

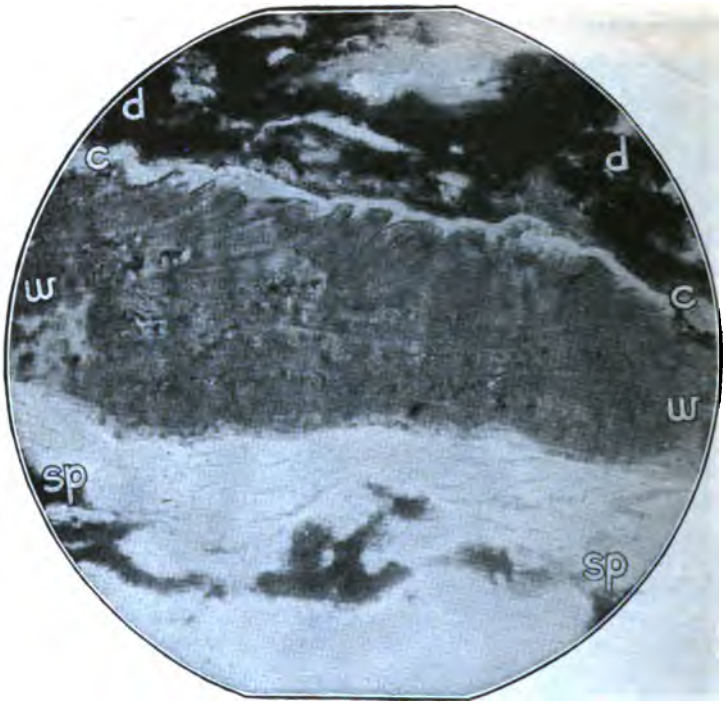
CROSS SECTIONS OF MEGASPORES IN COAL FROM BUXTON, IOWA. (X 40)



SPORE-EXINES IN COAL FROM BUXTON, IOWA.

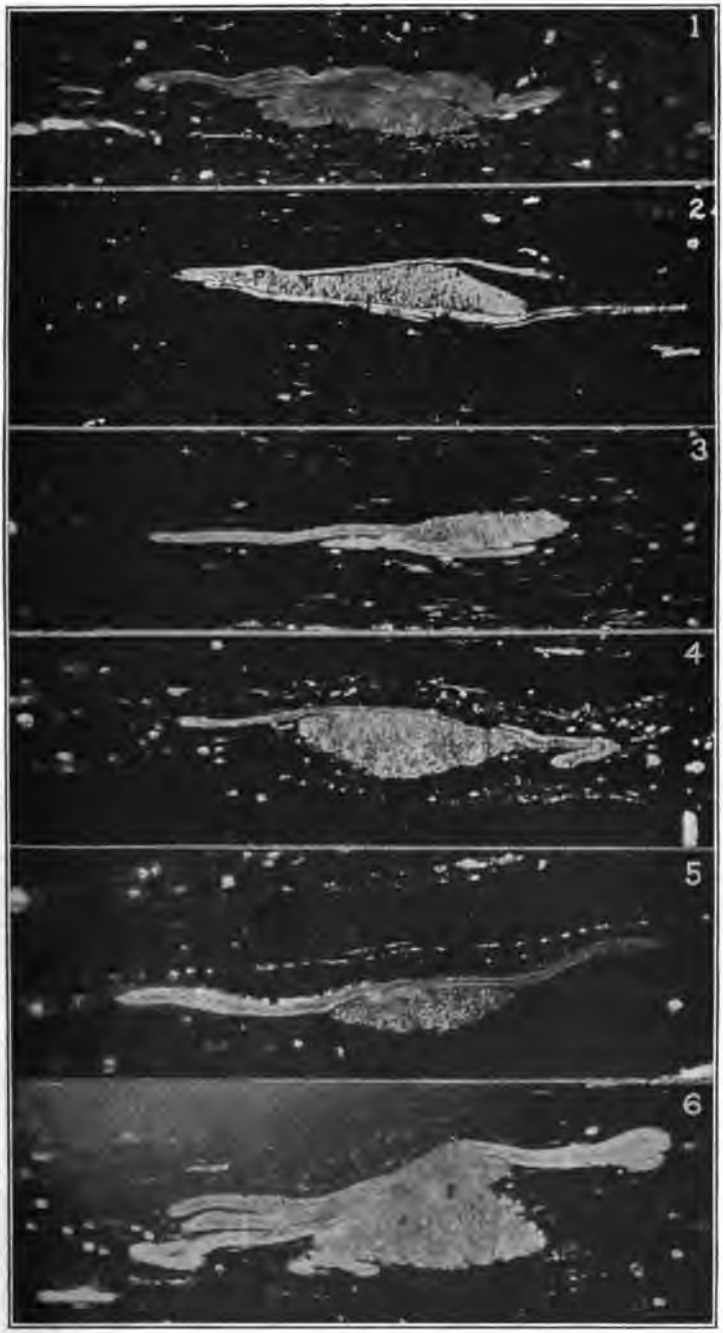
A. PART OF A SPORANGIUM IN THE COAL FROM BUXTON, IOWA. (X 200)

B. ANOTHER PART OF THE SAME SPORANGIUM AS THAT SHOWN ABOVE (X 200)

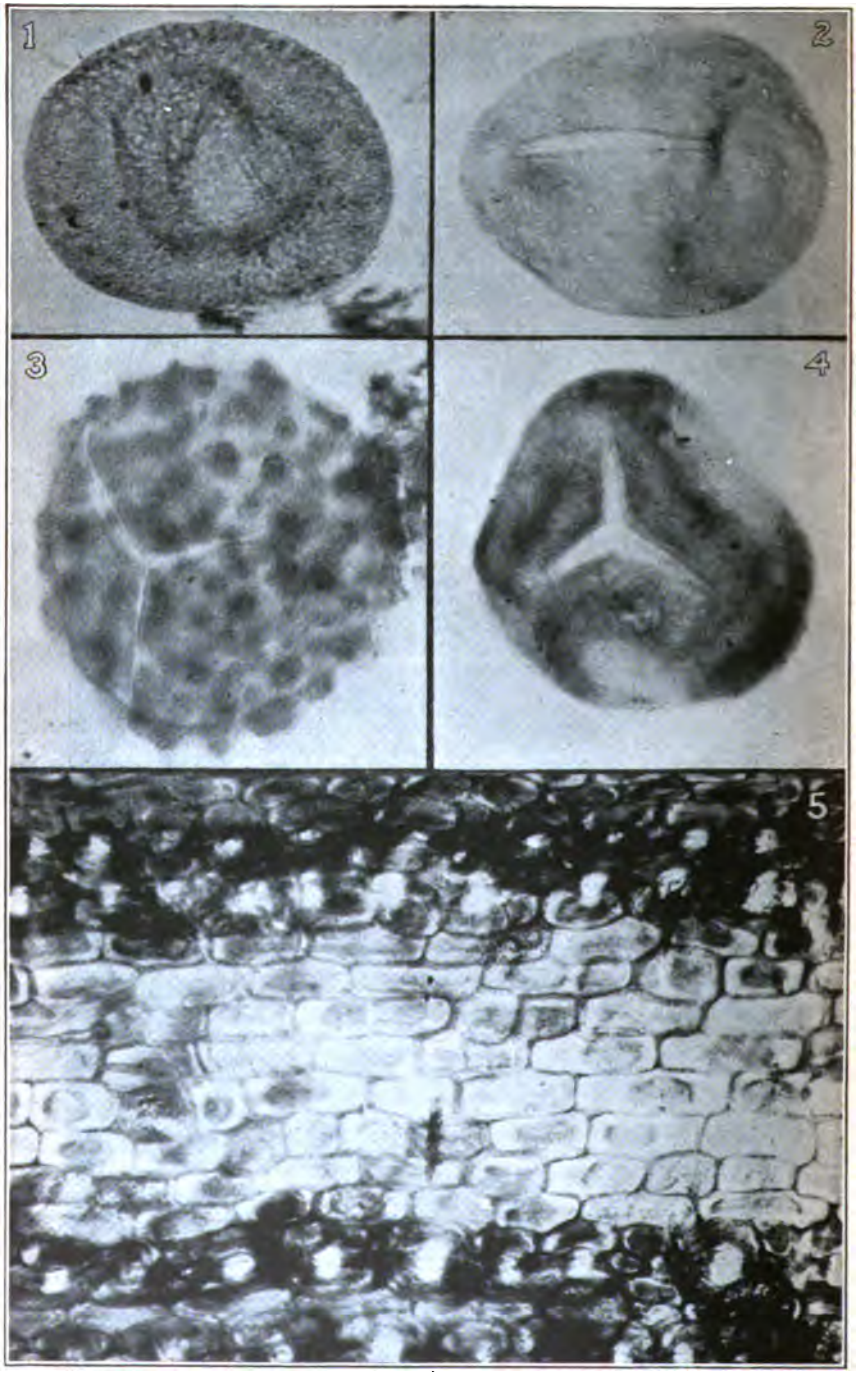


A. WALL OF SPORANGIUM SHOWN IN PLATE CXXXIII. (X 1000)

B. SPORE-EXINE MASS IN THE SPORANGIUM WALL SHOWN ABOVE (X 1000)



SPORES PARTLY COVERED WITH RAMENTA, IN THE ILLINOIS COALS.



SPORE-EXINES, POLLEN GRAIN, AND CUTICLE IN COAL FROM BUXTON, IOWA.

PLATE CXXXVII.

THIN VERTICAL SECTIONS OF THE SIPSEY COAL.

A. A thin cross section of coal from the Sipsey mine, Ala., photographed by means of transmitted light (×10), showing the general appearance of the "dull coal" and distribution and proportion of constituents. The anthraxylon strips are clearly distinguishable. Miscrospore-exines are represented by the small white specks, the megaspore-exines by the longer, narrow, areas.

B. A thin cross section of the coal from the Sipsey mine. (×200.) The attritus at 1–d consists largely of humic matter and small thin anthraxylon strips, considerable carbonaceous matter, and a few spore-exines; at 2–a is a light-colored anthraxylon chip showing cell structure; 3–d is carbonaceous matter.

PLATE CXXXVIII.

THIN VERTICAL SECTIONS.

A. A typical thin cross section of the Sipsey coal. (×200.) In the anthraxylon strip at 1–a the cells are folded and contorted. The "dull coal," 2–d to 4–d, is composed of an attritus relatively rich in spore-exines, little humic matter, and some carbonaceous and earthy matter. In this are embedded fragments of anthraxylon, plainly showing cell structure. Note the form of the spore-exines.

B. A typical thin cross section of the Sipsey coal (×200), showing an attritus rich in spore-exines and including a number of thin anthraxylon strips, a. The large majority of the spore-exines shown in all the photographs of the Sipsey coal are clearly of the same type, and differ from those of the other coals shown.

PLATE CXXXIX.

THIN VERTICAL SECTIONS.

A. A part of the section shown in Plate CXXXVIII, *B* (×1,000), containing a larger proportion of humic matter embedding spore-exines. The form of the spore-exines shown here differs from the predominant exines in the other coals shown.

B. Another part of the same section (×1,000), showing the nature of the spore-exines particularly well, also the nature of the other constituents.

PLATE CXL.

THIN HORIZONTAL SECTIONS.

A. A thin horizontal section of the Sipsey coal (×200), showing a portion of a tissue in which the cell structure is remarkably well preserved.

B. A part of the area shown in *A* (×1,000), showing the cell structure in detail. Notice the nuclei-like structures in the cells containing granules that seem to be chromosomes.

PLATE CXLI.

THIN HORIZONTAL SECTIONS.

A. A horizontal section of the Sipsey coal (×200), showing several kinds of tissues in which the cell structure is evident.

B. A view of one of the predominant spore-exines (×1,000) isolated from the coal of the Sipsey mine.

PLATE CXLII.

VERTICAL FRACTURE.

A vertical fracture of the Vandalia coal (×2), showing the layering of that coal. Notice the absence of thicker anthraxylon or "bright coal," and the presence of a large number of thin anthraxylon strips or chips.

PLATE CXLIII.

THIN CROSS SECTION OF THE VANDALIA COAL.

A. Thin cross section of the Vandalia coal (×10), photographed by means of transmitted light, showing the general structure of the coal of numerous thin anthraxylon chips with relatively little attritus between. The anthraxylon is represented by the grayish strips. The irregular dark areas c represent more highly carbonized matter; the small dark dots scattered throughout the section represent pyrite nodules.

B. Another section from the Vandalia coal prepared in a similar way as *A.* At 3–sp are a number of megaspore-exines; at 4–c some carbonaceous matter, and at 2–at a layer of attritus containing a larger number of spore-exines. The black dots, particularly abundant below 6–d, represent pyrite nodules.

PLATE CXLIV.

THIN HORIZONTAL SECTIONS.

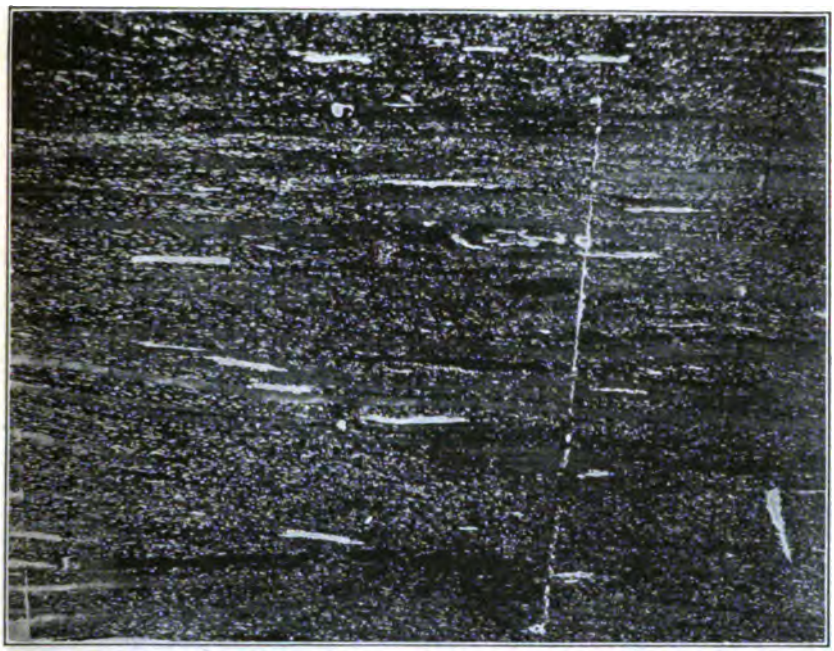
A and *B.* Thin horizontal sections of the Vandalia coal, prepared by means of transmitted light (×10). The anthraxylon components in gray appear to be homogeneous, and the attritus to be heterogeneous. The irregular black areas represent bits of charcoal or more highly carbonized particles.

PLATE CXLV.

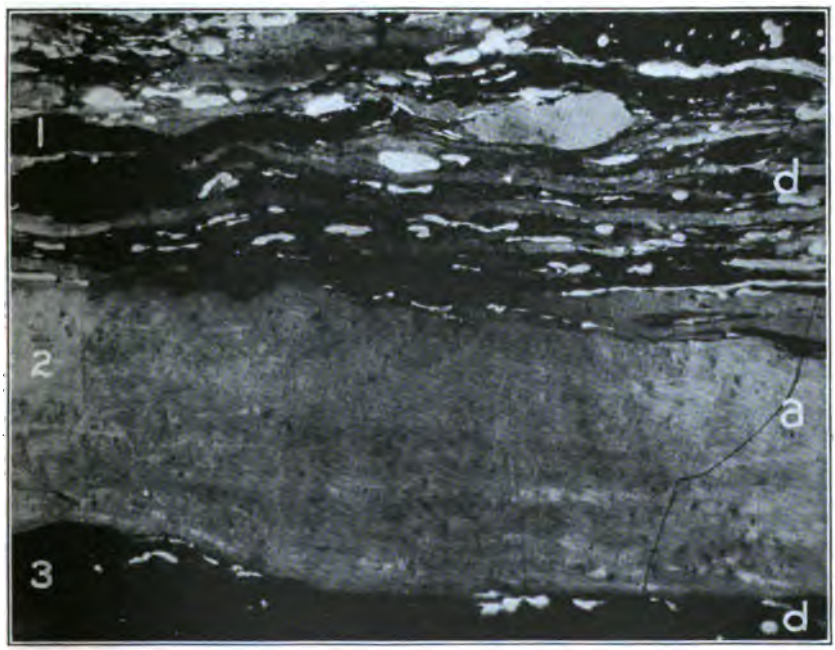
THIN HORIZONTAL SECTION.

B A thin horizontal section of the Vandalia coal (×150) cutting obliquely through a layer of attritus. The attritus is composed of anthraxylon and humic matter, in which cells and fibers are clearly recognizable, and some charred matter. A few spore-exines are recognizable.

B. A thin horizontal section of the Vandalia coal (×150) cutting obliquely through a thin strip of anthraxylon. The black dots in the upper part represent pyrite particles. Wood fiber and woody structures are clearly shown.



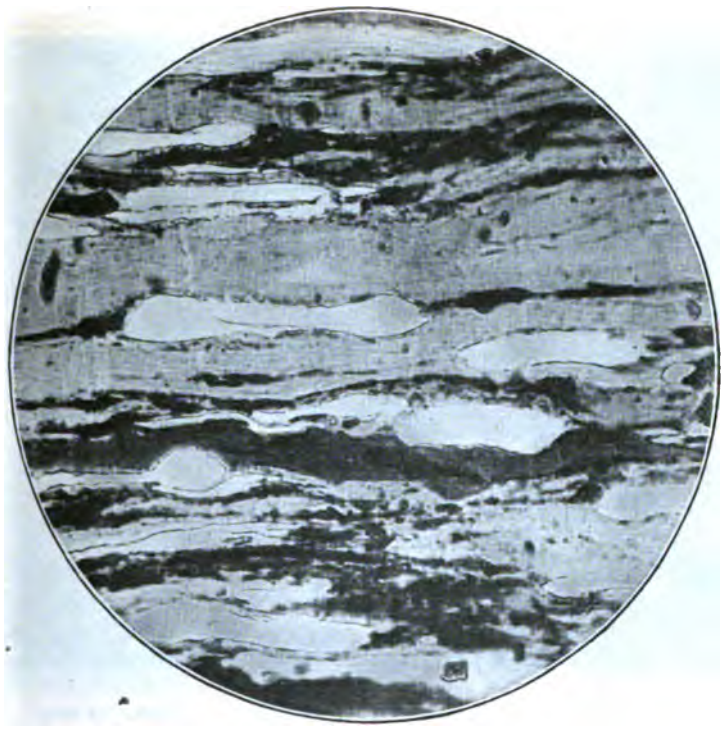
A. THIN VERTICAL SECTION OF COAL FROM THE SIPSEY MINE, ALA., AT LOW MAGNIFICATION. (X 10)



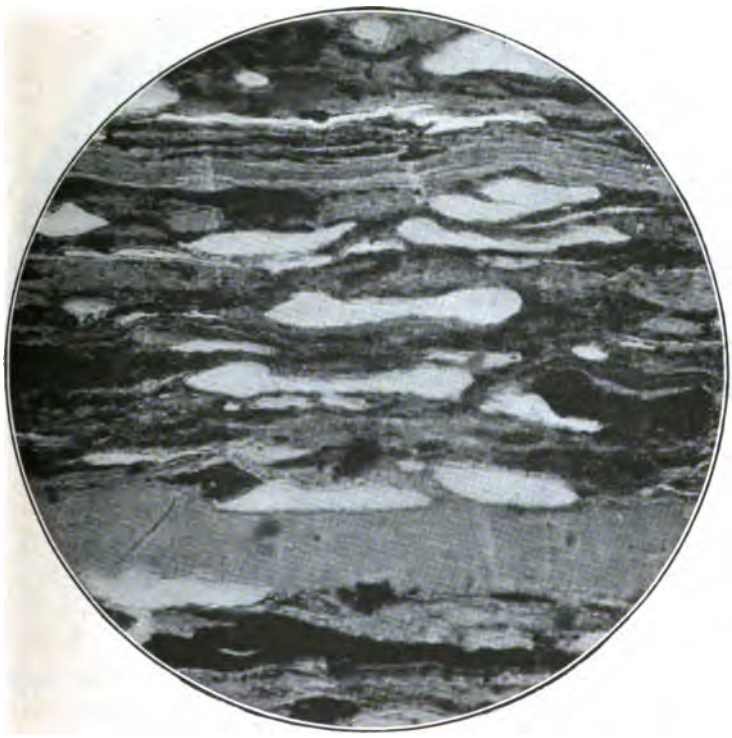
B. THIN VERTICAL SECTION OF COAL FROM THE SIPSEY MINE, SHOWING ATTRITUS. (X 200)

A. THIN VERTICAL SECTION OF THE COAL FROM THE SIPSEY MINE (X 200), SHOWING ANTHRAXYLON AND "DULL COAL" LAYERS.

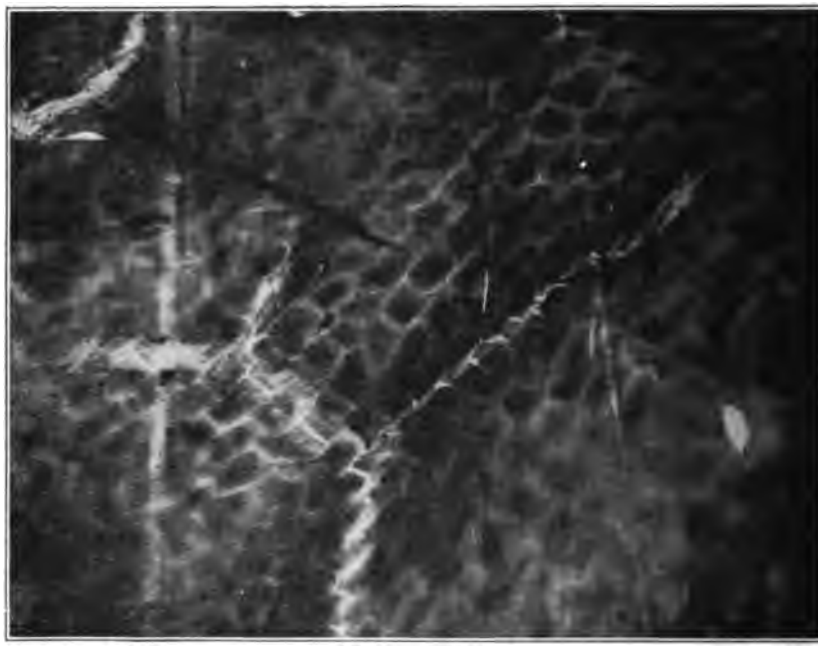
B. THIN VERTICAL SECTION OF THE COAL FROM THE SIPSEY MINE (X 200), SHOWING SPORE-EXINES AND ANTHRAXYLON.



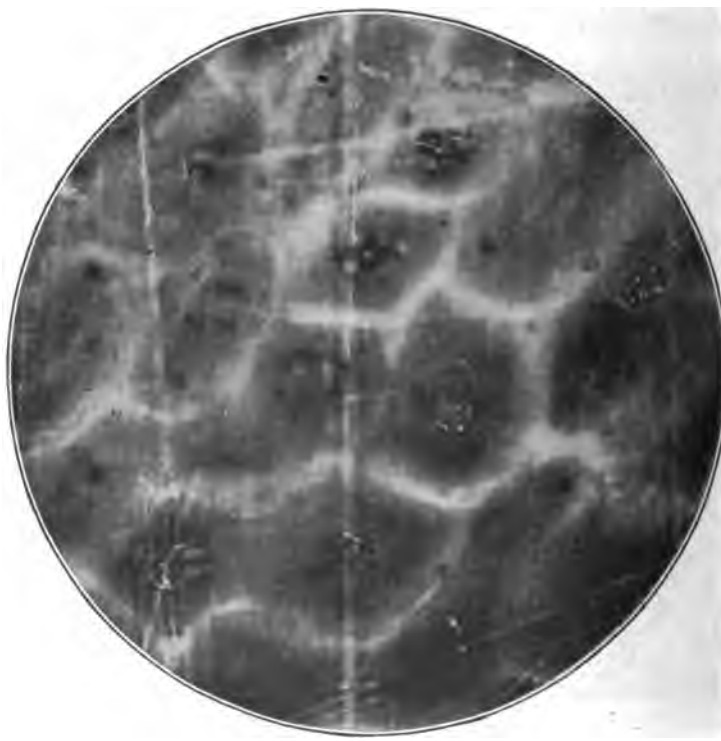
A. PART OF THE SECTION SHOWN IN PLATE CXXXVIII, *B*. (X 1000)



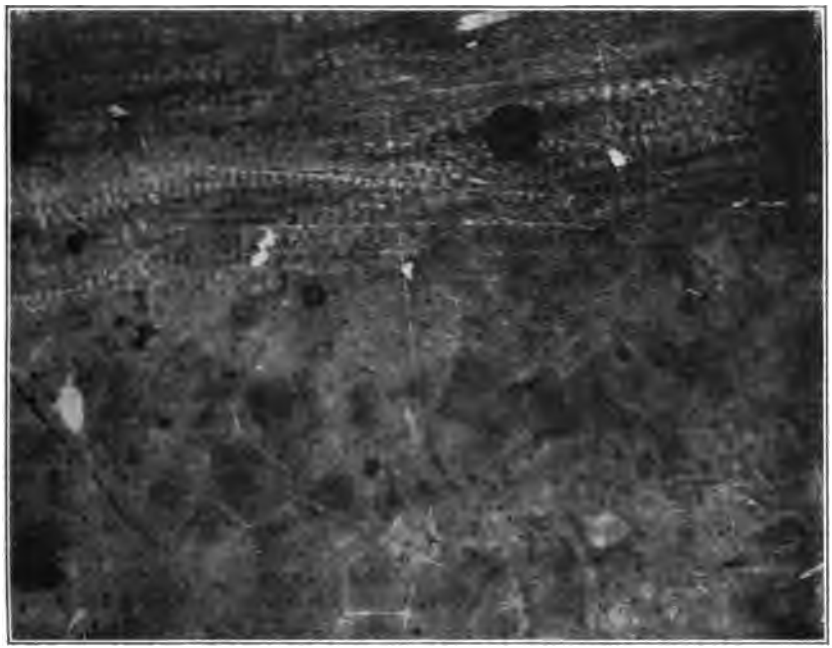
B. ANOTHER PART OF THE SECTION SHOWN IN PLATE CXXXVIII, *B*. (X 1000)



A. CELL TISSUE IN COAL FROM THE SIPSEY MINE. (X 200)

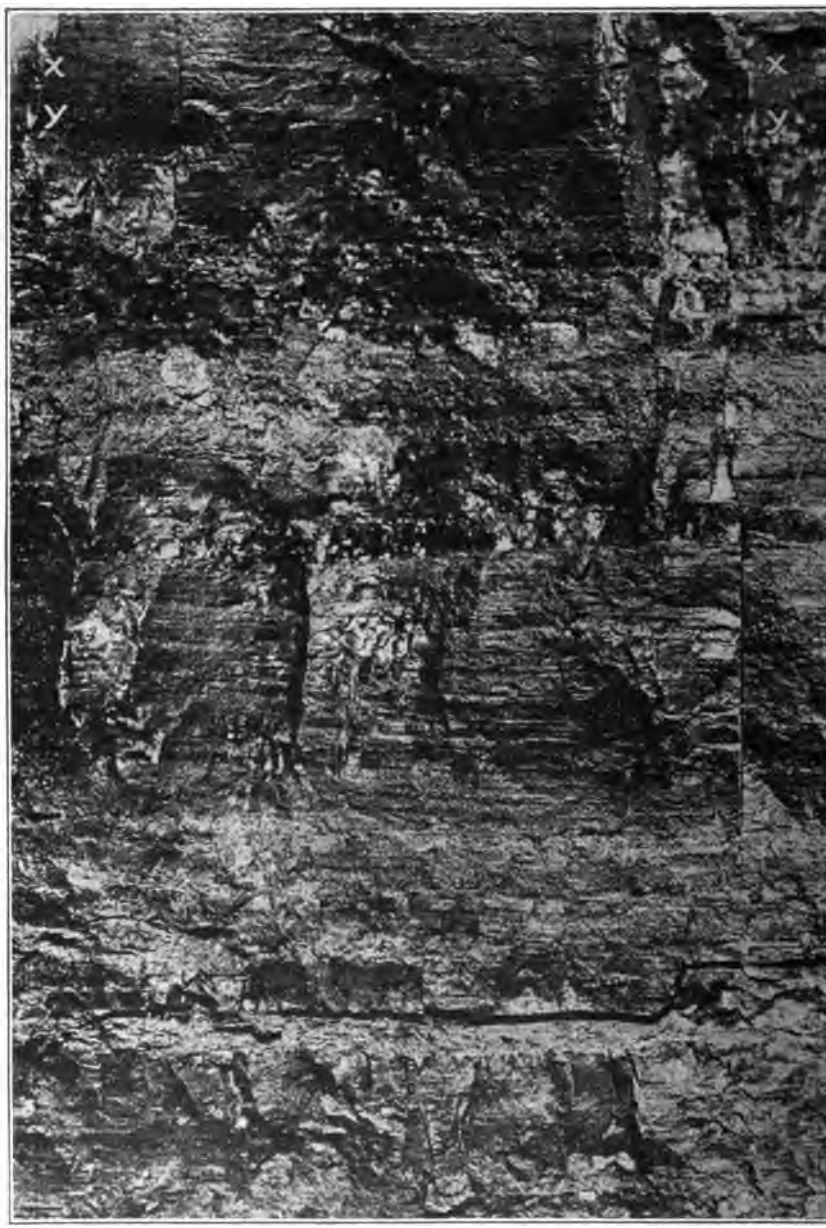


B. PART OF THE SECTION SHOWN ABOVE. (X 1000)



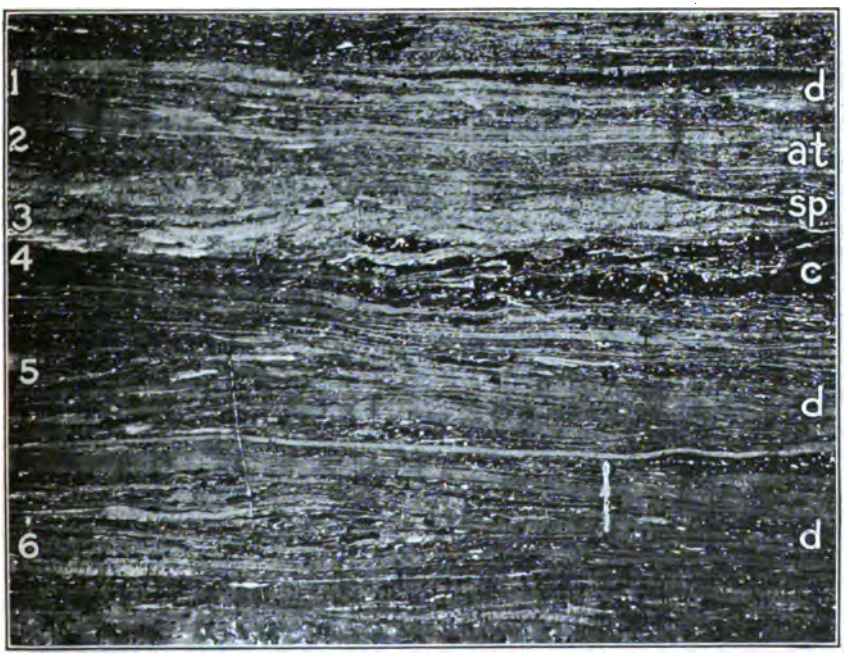
A. THIN HORIZONTAL SECTION OF THE COAL FROM THE SIPSEY MINE. (X 200)

B. SPORE-EXINE ISOLATED FROM THE SIPSEY COAL. (X 1000)

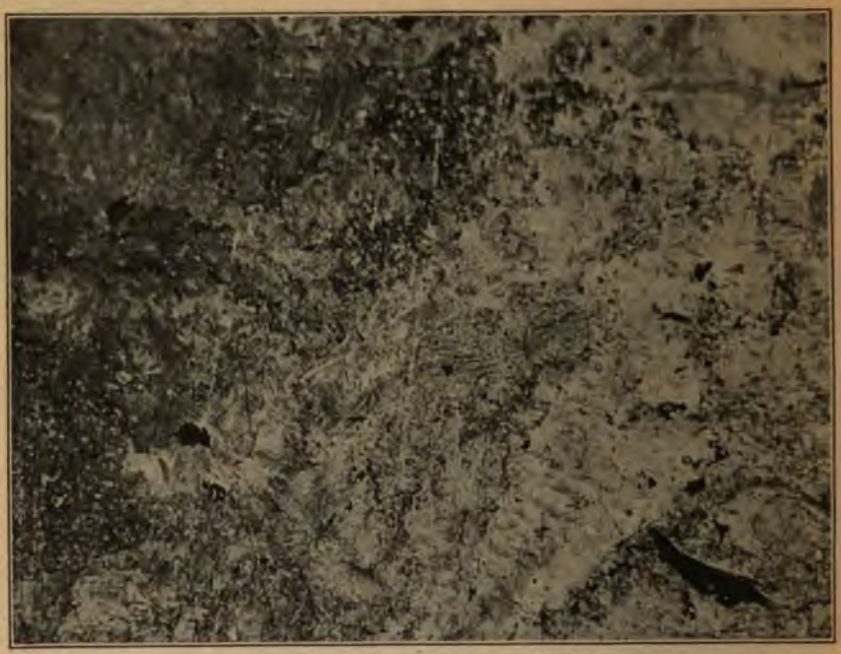


VERTICAL FRACTURE OF THE COAL FROM THE VANDALIA MINE, NEAR TERRE HAUTE, IND. (X 2)

A. THIN VERTICAL SECTION OF COAL FROM THE VANDALIA MINE, AT LOW MAGNIFICATION. (X 10)



B. ANOTHER VERTICAL SECTION OF THE VANDALIA COAL AT LOW MAGNIFICATION. (X 10)



A. THIN HORIZONTAL SECTION OF THE VANDALIA COAL, AT LOW MAGNIFICATION. (X 10)

B. ANOTHER HORIZONTAL SECTION OF THE VANDALIA COAL, AT LOW MAGNIFICATION. (X 10)

PLATE CXLVI.

THIN VERTICAL SECTIONS.

A. A thin cross section (×200) of the coal from Vandalia, Ind. 1–a represents a thicker anthraxylon, corresponding to one of the thin strips shown in cross section in Plate CXLIII, *A* and *B;* 2–c represents cuticular matter; at 3–d is seen a thin layer composed of small anthraxylon chips, including some carbonized matter, a few spore-exines, and also several pyrite particles; 4–a is a layer consisting of spore-exines and humic matter; the layer 5–d is composed of small anthraxylon chips, humic matter, more highly carbonized matter, pyrite granules and some spore matter. The small, dark, rounded and irregular areas represent pyrite nodules.

B. A thin cross section of the Vandalia coal. (×200.) The layer at 1–a represents a resinous strip of anthraxylon corresponding to one of the thin strips shown in Plate CXLIII, *A* and *B;* 2–d, a layer of attritus composed of humic matter, carbonaceous matter and spore matter; 3–d represents a sheet of closely packed resinous particles; 4–a, a layer consisting of a number of thin anthraxylon chips, including very light-colored strips of a cuticular nature; 5–d represents a layer of attritus of varied composition. The small dark rounded and irregular areas represents pyrite granules or nodules.

PLATE CXLVII.

THIN VERTICAL SECTIONS.

A. Thin cross section of the Vandalia coal (×200), representing a layer composed largely of resinous matter, small anthraxylon chips, and humic matter, and a small amount of spore matter, carbonaceous matter, and pyrite granules.

B. A thin cross section of the Vandalia coal (×200), representing a layer similar to that shown in *A*, but in which the particles of resinous matter differ in texture, size, and form. The matter lodged between the resinous matter at 2–a and 3–a is the residue of a once woody tissue.

PLATE CXLVIII.

THIN VERTICAL SECTIONS.

A. A thin cross section of the Vandalia coal. (×200.) At 1–a is a layer of thin anthraxylon strips; at 2–d is a layer of attritus containing much resinous matter, humic matter, some carbonaceous matter, and a little spore matter; 3–a is a layer that consists almost entirely of large irregularly shaped resinous particles with some of the interstices filled with an earthy matter.

B. A thin cross section of the Vandalia coal. (×200.) At 1–d is a layer of humic matter, spore-exines that are not well preserved, and some resinous matter; 2–a is an anthraxylon strip; at 3–d and 4–d are layers containing much resinous matter, large irregular particles of humic matter and some spore and earthy matter.

PLATE CXLIX.

THIN VERTICAL SECTIONS.

A. A thin cross section of the Vandalia coal, the first of a series of three photographs (×200), representing parts of the same resinous anthraxylon strip in various stages of decay. At 1–a the strip is partly "decayed," leaving much resinous matter. In the lower part, at 2–d, 3–a, and 4–d, a number of anthraxylon strips, humic matter, and a few resinous particles and spore-exines are embedded in an earthy and carbonaceous matrix.

B. A thin cross section of the Vandalia coal, the second of a series of three photographs (×200) of the same resinous anthraxylon strip. Practically all the woody matter has disappeared, leaving nothing but the resinous particles; some of the interstices are filled with an earthy matter, chiefly pyrite, and some of the interstices are empty spaces; at 3–a there still remains some of the original woody tissue.

PLATE CL.

THIN VERTICAL SECTIONS.

A. A thin cross section of the Vandalia coal, the third of a series of three photographs (×200), of the same anthraxylon chip, in various stages of decay, showing a part of the strip in which much of the woody matter is still holding the resinous particles in situ.

B. A thin cross section of the Vandalia coal (×1,000), showing a layer of attritus containing a number of spore-exines, some humic matter and carbonaceous matter.

PLATE CLI.

CROSS SECTIONS OF STEM OF A FOSSIL MEDULLOSA.

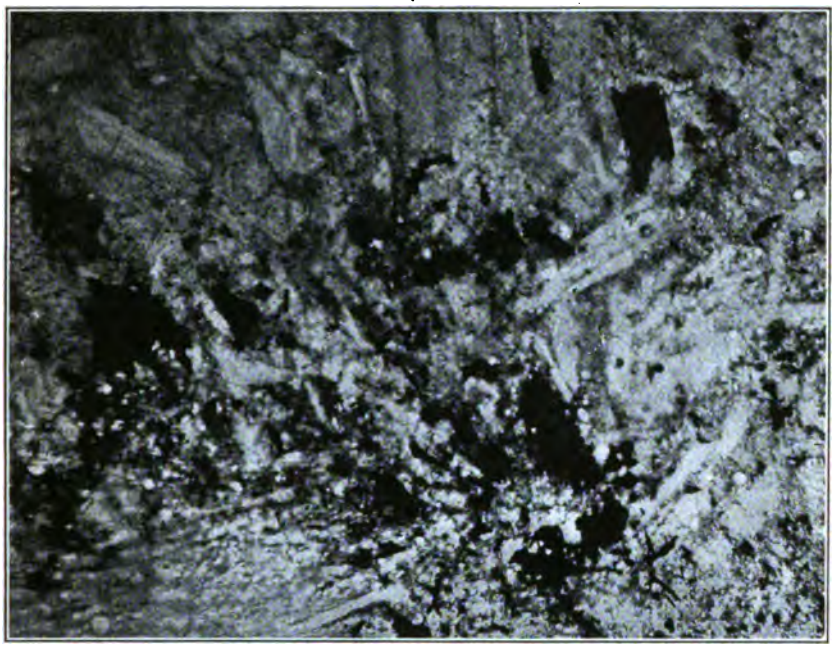
A. The cross section (×5) of the stem of a fossil medullosa (M. Anglica). In the center are the three steles of wood, surrounded by a common periderm, p. Outside of this is the inner cortex, ic, and forming the outer covering of this is the outer cortex oc. In the outer and the inner cortices leaf traces and gum canals, or mucilage ducts, run in a vertical direction. The leaf traces are faintly shown as small irregular and rounded areas, the gum canals as small circular areas, quite distinct in some places.

B. Part of the inner cortex ic in *A*, split longitudinally (×10) of the stem shown in *A*, in which several gum canals filled with some matter, m, are seen, and leaf traces, lt.

PLATE CLII.

LONGITUDINAL SPLIT OF STEM OF A FOSSIL MEDULLOSA.

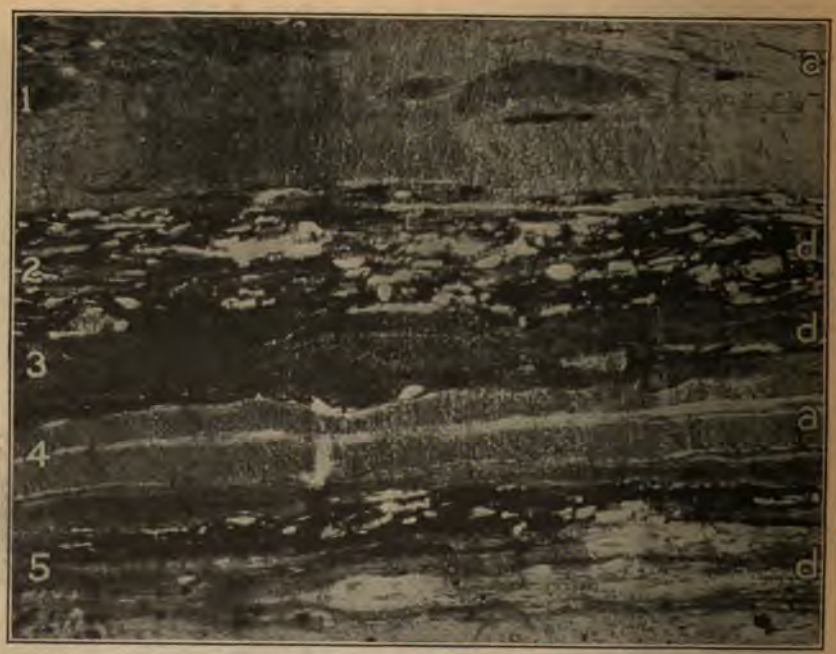
Another longitudinal split (×10) of the stem shown in Plate CLI, *A*, partly in one of the steles and partly in the cortex; st, stele, showing the wood of the plant; lt, leaf trace; m, gum canals or mucilage ducts; pd, periderm.



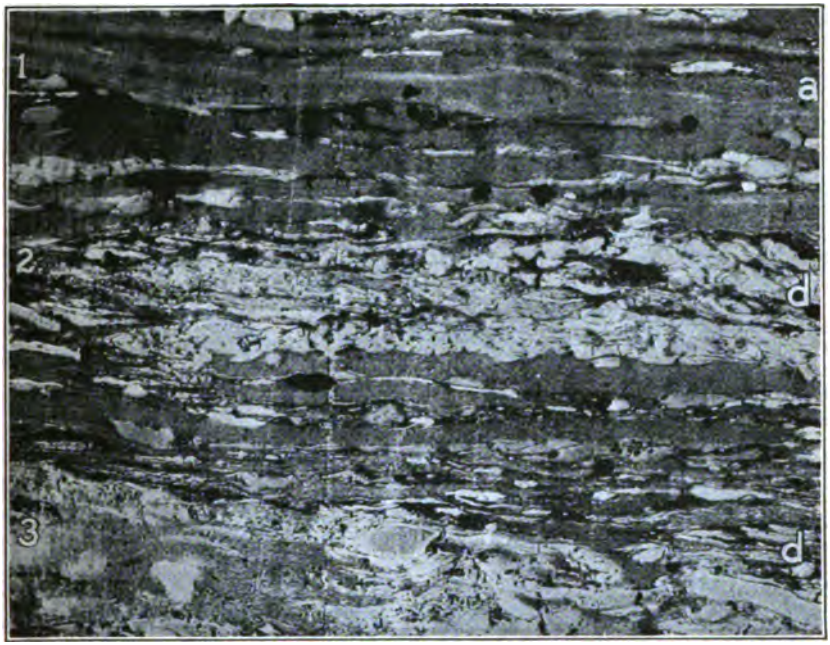
A. THIN HORIZONTAL SECTION OF VANDALIA COAL, CUT OBLIQUELY THROUGH LAYER OF ATTRITUS. (X 150)

B. OBLIQUE SECTION THROUGH STRIP OF ANTHRAXYLON. (X 150)

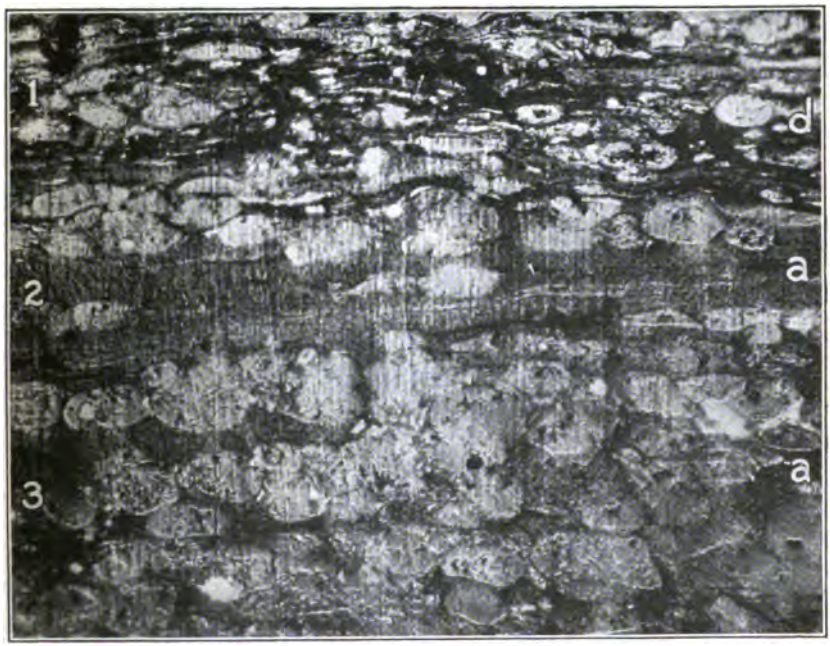
A. THIN VERTICAL SECTION OF COAL FROM THE VANDALIA MINE, SHOWING VARIOUS COMPONENTS. (X 200)



B. ANOTHER THIN VERTICAL SECTION OF THE COAL FROM THE VANDALIA MINE, SHOWING VARIOUS COMPONENTS. (X 200)



A. THIN VERTICAL SECTION OF COAL FROM THE VANDALIA MINE, SHOWING MUCH RESINOUS MATTER. (X 200)

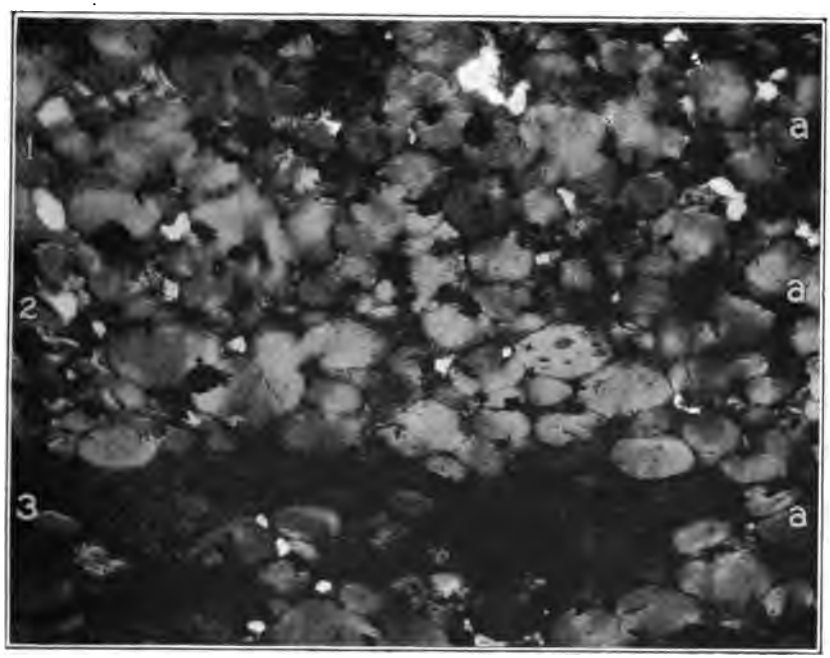


B. ANOTHER THIN VERTICAL SECTION OF THE COAL FROM THE VANDALIA MINE, SHOWING RESINOUS LAYERS. (X 200)

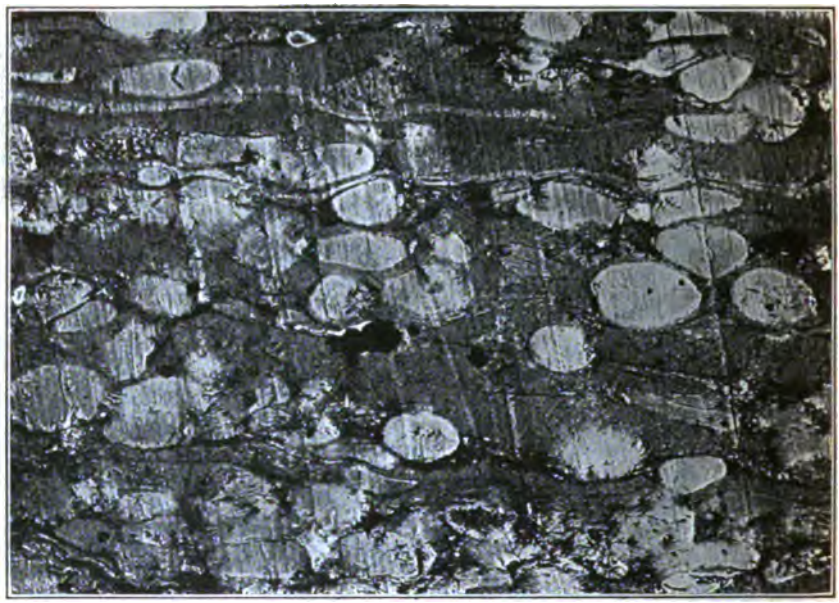
A. THIN VERTICAL SECTION OF COAL FROM THE VANDALIA MINE, SHOWING ANTHRAXYLON, MIXED ATTRITUS, AND RESINOUS LAYER. (X 200)

B. THIN VERTICAL SECTION OF THE VANDALIA COAL, SHOWING LAYERS OF DIFFERENT CONSTITUENTS. (X 200).

A. THE FIRST OF A SERIES OF THREE SECTIONS OF VANDALIA COAL, REPRESENTING RESINOUS ANTHRAXYLON IN VARIOUS STAGES OF DECAY. (X 200)

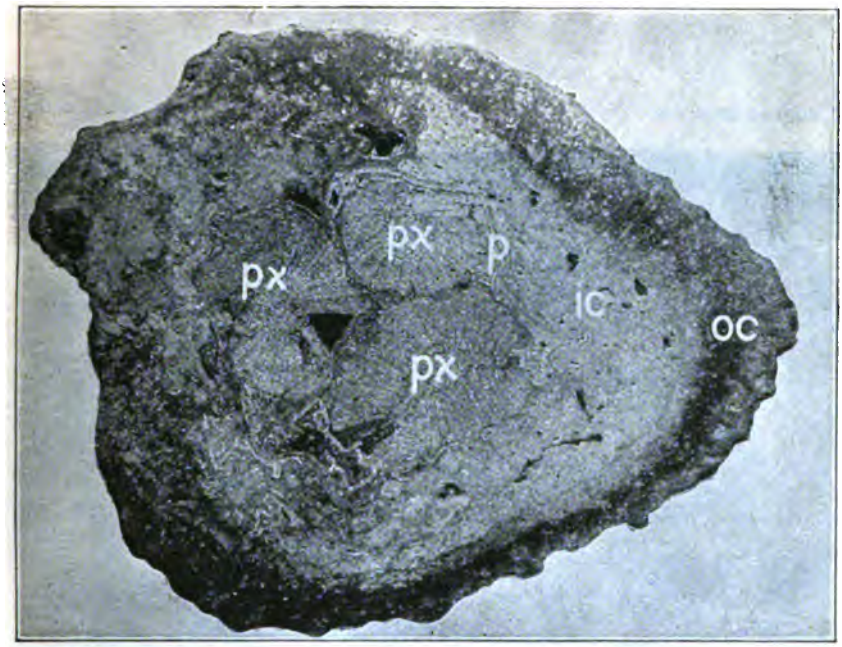


B. SECOND SECTION OF THE SERIES. (X 200)

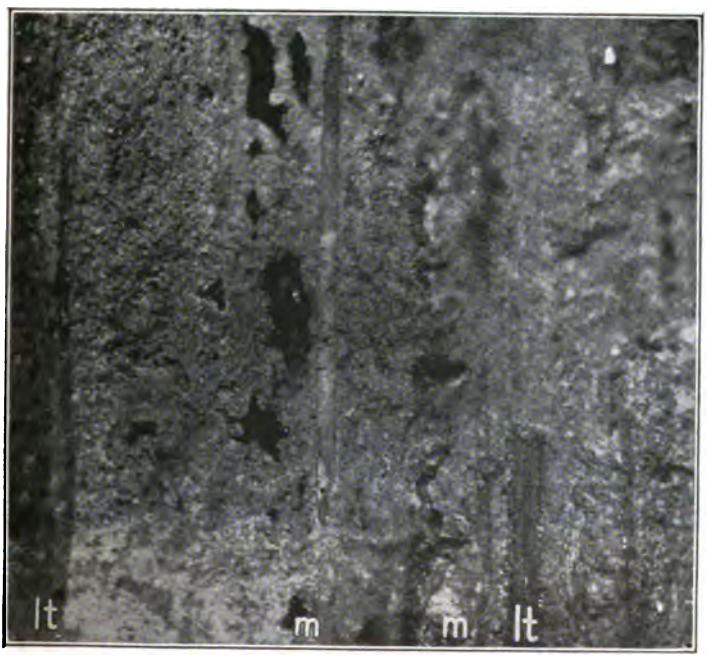


A. THIRD SECTION OF THE SERIES, SHOWING DECAY OF RESINOUS ANTHRAXYLON. (X 200)

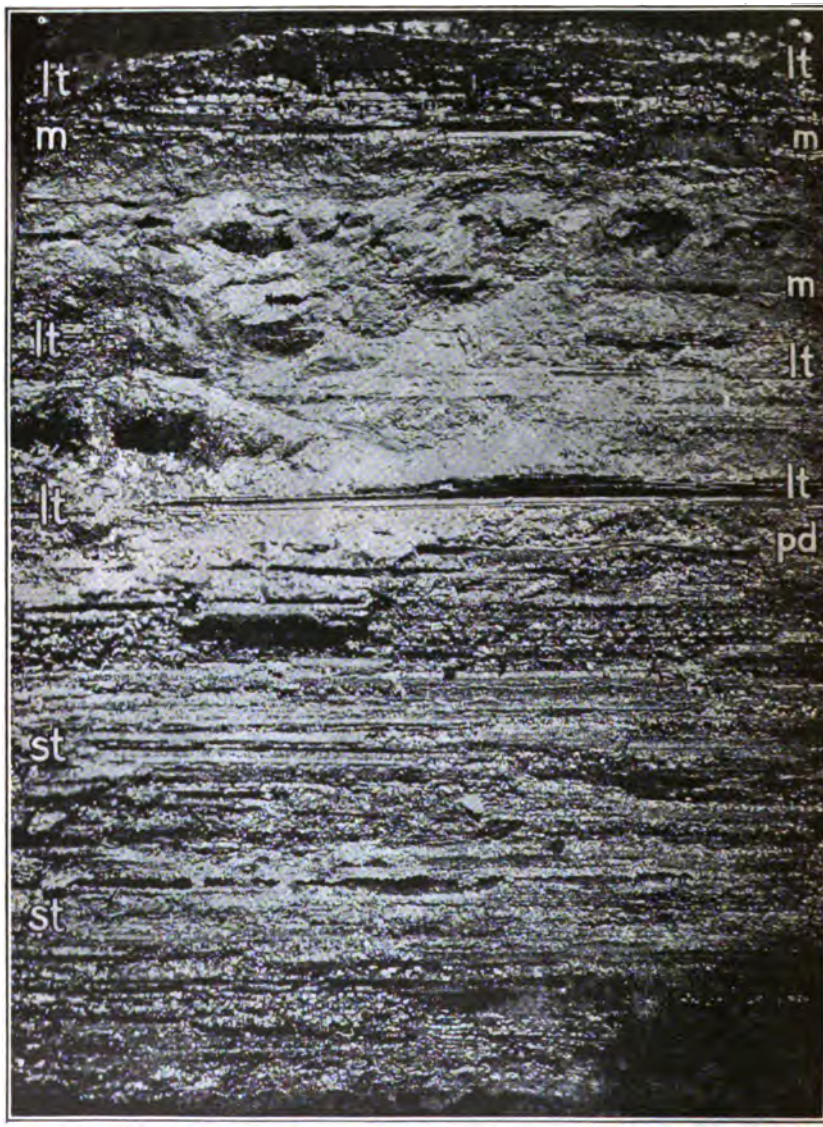
B. THIN VERTICAL SECTION OF THE VANDALIA COAL, VERY HIGHLY MAGNIFIED. (X 1000)



A. CROSS SECTION OF THE STEM OF A FOSSIL MEDULLOSA. (X 5)



B. LONGITUDINAL SECTION OF INNER CORTEX (IC) SHOWN ABOVE (X 10)



LONGITUDINAL SECTION OF A STELE AND THE INNER CORTEX SHOWN IN PLATE CLI, *A*. (X 10)

PLATE CLIII.

LONGITUDINAL SPLIT OF CORTICES OF A FOSSIL MEDULLOSA.

A split through the same stem shown in Plate CLI, *A* (×10) from the outer to the inner cortex. Oc, outer cortex; ic, inner cortex; m, mucilage ducts or gum canals; lt, leaf traces.

PLATE CLIV.

MEDULLOSA-LIKE STRUCTURE.

A. A horizontal fracture of the Shelbyville coal (×10), showing medullosa-like structure, with vascular strands or leaf traces, vs, and "needles," m, in the cortex or parenchyma, p.

B. A horizontal fracture from the Shelbyville coal (×10), showing medullosa-like structure of a type similar to yet slightly different from that shown in *A*. m, needles; vs, vascular strands or leaf traces in the cortex or parenchyma, p.

PLATE CLV.

MEDULLOSA-LIKE STRUCTURE.

A horizontal fracture of the Zeigler coal (×5), showing a medullosa-like structure different from the type in the Shelbyville coal. The needles are associated with the vascular strands or strands of woody tissue and are much thinner than in the type shown previously; they are distinctly seen in some of the vascular strands, vs. The cortex or parenchyma is represented by p.

PLATE CLVI.

RODLETS.

A cleavage surface of the Royalton coal (×25), photographed by means of reflected light, showing the magnified appearance of one of the "needles" or "rodlets." In the upper left-hand corner is also shown one of the needles composed of quartz, in an oblique transverse fracture.

PLATE CLVII.

FUNGAL HYPHÆ.

A. A thin horizontal section of the Vandalia coal (×1000), showing anthraxylon pervaded by fungal hyphæ.

B. Another horizontal section of the Vandalia coal (×1,000) showing an anthraxylon chip infested by fungal hyphæ with spore-like thickenings.

PLATE CLVIII.

FUNGAL-LIKE BODIES.

A. A thin horizontal section of the coal from the experimental mine of the Bureau of Mines (×150), showing a portion of a sporangium infested by organisms like fungal spores, shown as minute white dots among the spore-exines.

B. A part of the section shown in *A*. (×1,000.) The bodies like fungal spores are shown as small white areas among the spore-exines.

PLATE CLIX.

FUNGAL-LIKE BODIES.

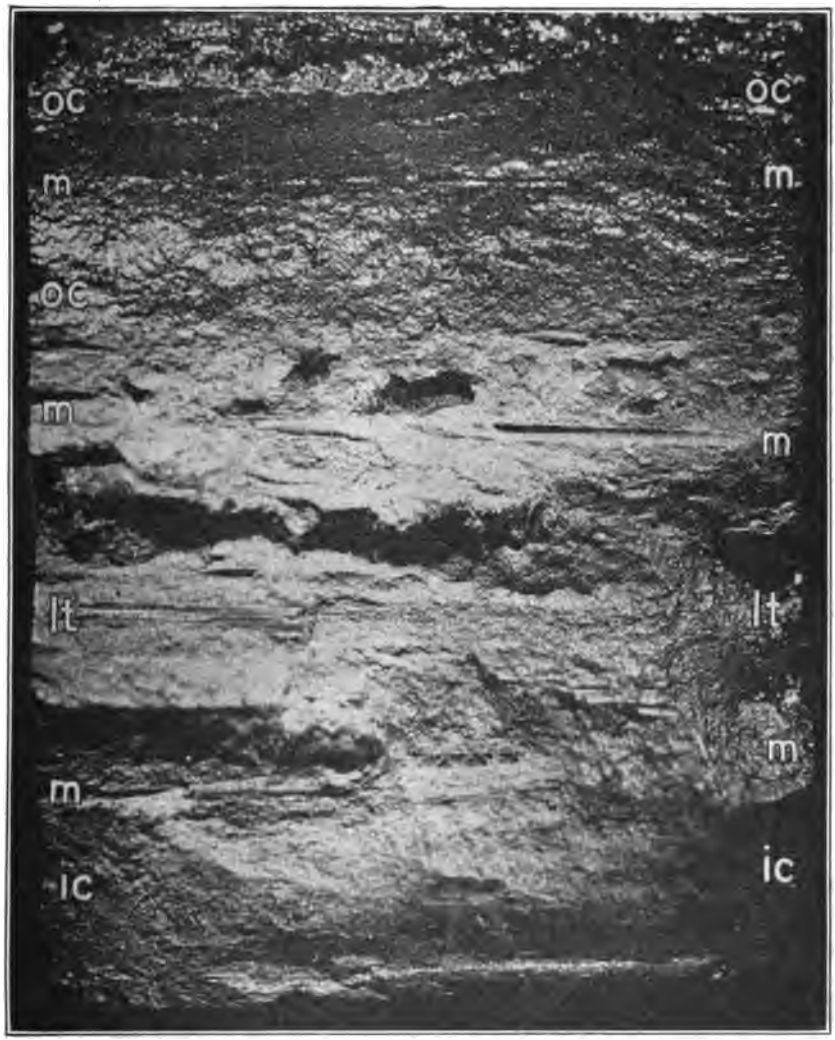
A and *B*. Two other parts of the horizontal section shown in Plate CLVIII, *A* (×1,000), showing the same fungal-like bodies among the spore-exines.

PLATE CLX.

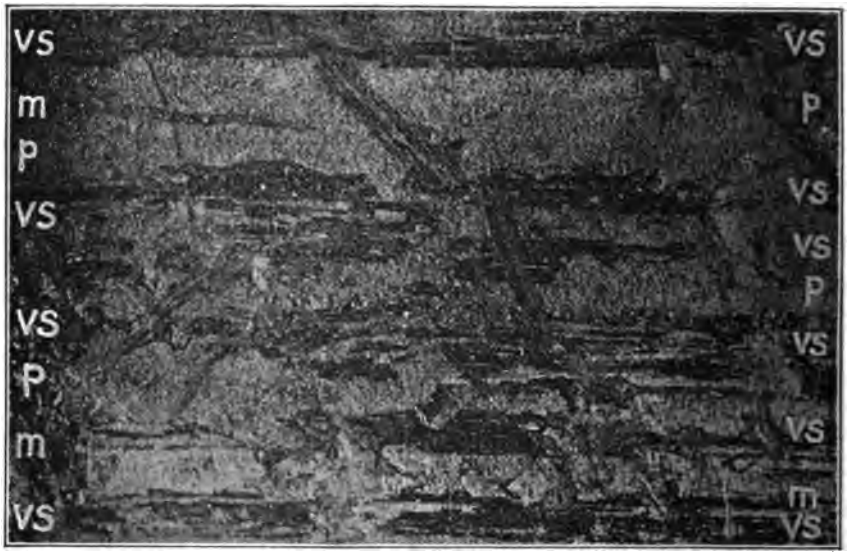
UNKNOWN ORGANISMS.

A. A horizontal thin section (×1,000) from the coal from the experimental mine of the Bureau of Mines, showing an unknown organism consisting of very small ovoid bodies, usually arranged in ring-like groups.

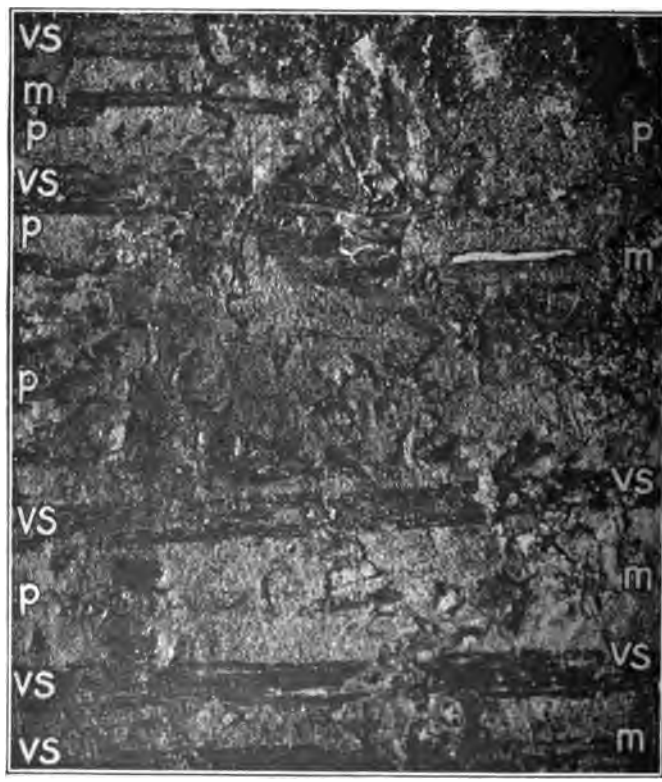
B. Another horizontal thin section (×1,000) from the coal from the experimental mine, showing the same organisms as in *A*. A spore-exine of the predominant type is seen in the center and serves as a standard for comparison. The diameter of the spore-exine is approximately 15 microns.



LONGITUDINAL SECTION OF INNER AND OUTER CORTEX SHOWN IN PLATE CLI, *A*. (X 10)



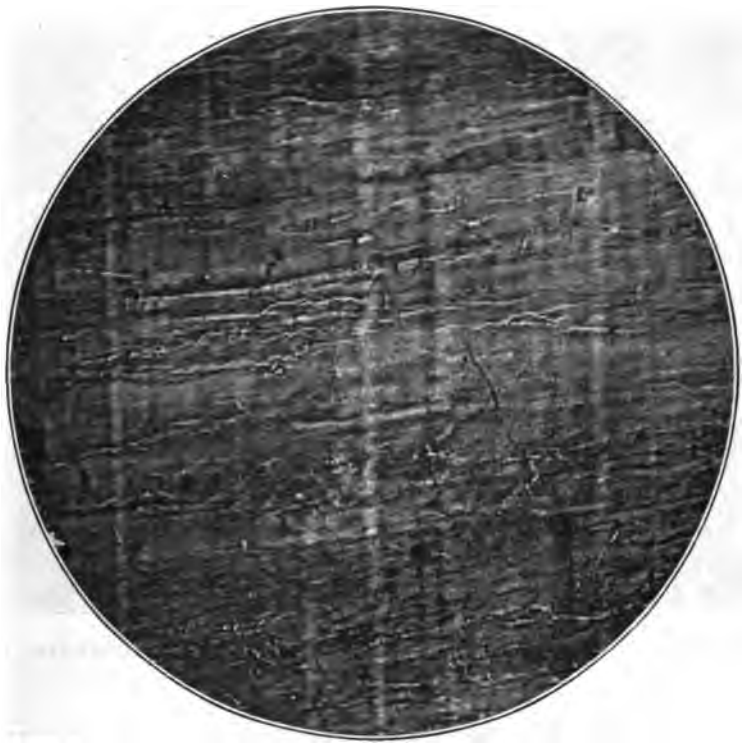
A. MEDULLOSA-LIKE STRUCTURE IN COAL FROM SHELBYVILLE, ILL. (X 10)



B. ANOTHER HORIZONTAL FRACTURE IN SHELBYVILLE COAL, SHOWING MEDULLOSA-LIKE STRUCTURE. (X 10)

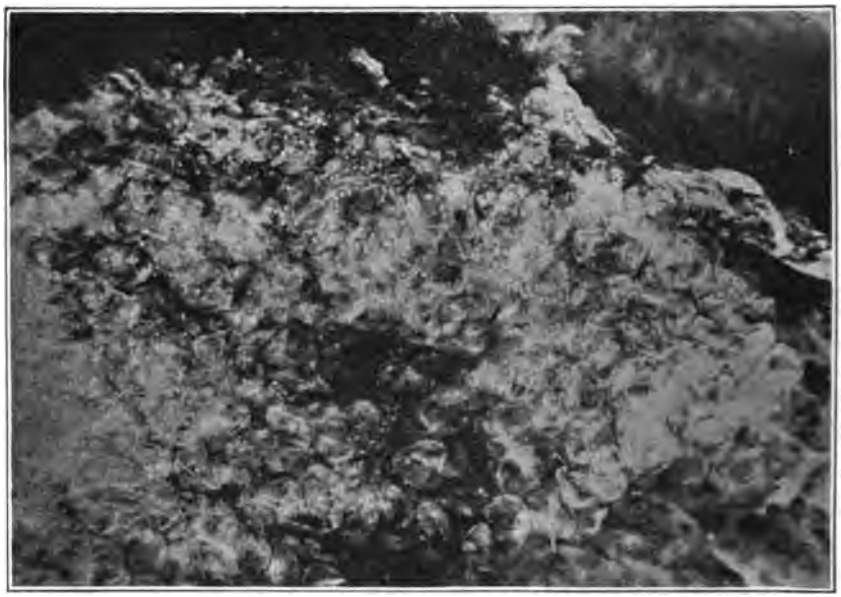
MEDULLOSA-LIKE STRUCTURE IN COAL FROM ZEIGLER, ILL. (X 5)

RODLETS IN COAL FROM ROYALTON, ILL. (X 25)



A. FUNGAL HYPHÆ IN COAL FROM VANDALIA, ILL. (X 1000)

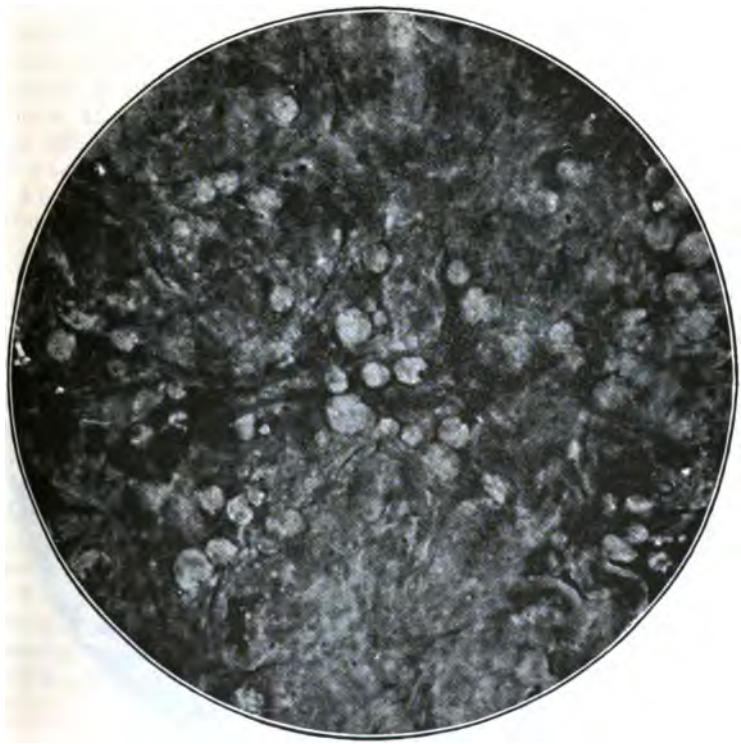
B. ANOTHER SECTION SHOWING FUNGAL HYPHÆ IN COAL FROM VANDALIA, ILL. (X 1000)



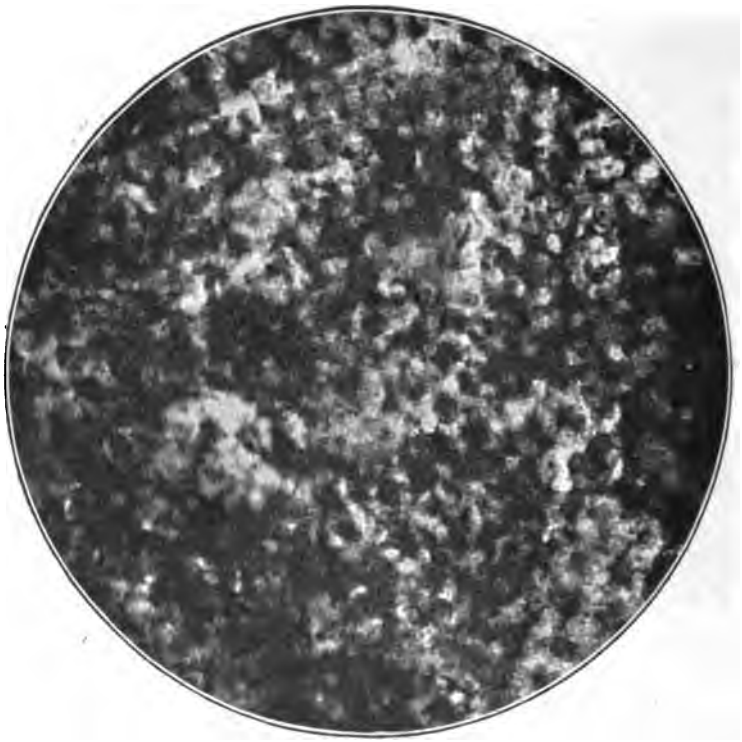
A. BODIES LIKE FUNGAL SPORES IN COAL FROM THE EXPERIMENTAL MINE. (X 150)

B. PART OF THE SECTION SHOWN ABOVE. (X 1000)

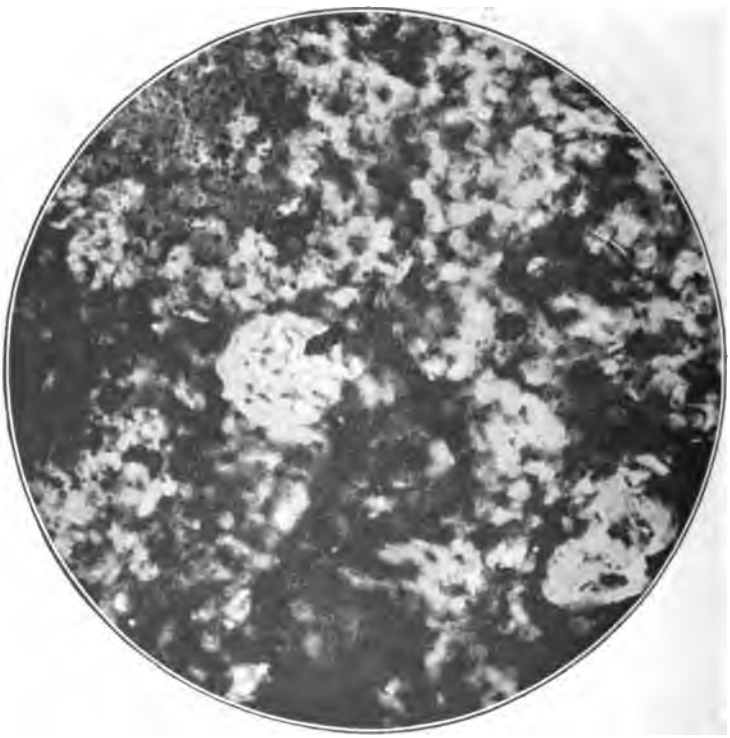
A. ANOTHER AREA FROM THE SECTION SHOWN IN PLATE CLVIII, *A*. (X 1000)



B. A THIRD AREA FROM THE SECTION SHOWN IN PLATE CLVIII, *A*. (X 1000)



A. A SECTION OF COAL FROM THE EXPERIMENTAL MINE, SHOWING UNKNOWN ORGANISMS. (X 1000)



B. ANOTHER VIEW OF UNKNOWN ORGANISMS IN COAL FROM THE EXPERIMENTAL MINE. (X 1000)

PUBLICATIONS ON THE COMPOSITION OF COAL.

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PUBLICATIONS AVAILABLE FOR FREE DISTRIBUTION.

BULLETIN 85. Analyses of mine and car samples of coal collected in the fiscal years 1911 to 1913, by A. C. Fieldner, H. I. Smith, A. H. Fay, and Samuel Sanford. 1914. 444 pp., 2 figs.

BULLETIN 119. Analyses of coals purchased by the Government during the fiscal years 1908–1915, by G. S. Pope. 1916. 118 pp.

BULLETIN 136. Deterioration in the heating value of coal during storage, by H. C. Porter and F. K. Ovitz. 1917. 38 pp., 7 pls.

TECHNICAL PAPER 2. The escape of gas from coal, by H. C. Porter and F. K. Ovitz. 1911. 14 pp., 1 fig.

TECHNICAL PAPER 5. Constituents of coal soluble in phenol, by J. C. W. Frazer and E. J. Hoffman. 1912. 20 pp., 1 pl.

TECHNICAL PAPER 8. Methods of analyzing coal and coke, by F. M. Stanton and A. C. Fieldner. 1913. 42 pp., 12 figs.

TECHNICAL PAPER 16. Deterioration and spontaneous heating of coal in storage, a preliminary report, by H. C. Porter and F. K. Ovitz. 1912. 14 pp.

TECHNICAL PAPER 35. Weathering of the Pittsburgh coal bed at the experimental mine near Bruceton, Pa., by H. C. Porter and A. C. Fieldner. 1914. 35 pp., 14 figs.

TECHNICAL PAPER 64. The determination of nitrogen in coal, a comparison of various modifications of the Kjeldahl method with the Dumas method, by A. C. Fieldner and C. A. Taylor. 1915. 23 pp., 5 figs.

TECHNICAL PAPER 76. Notes on the sampling and analysis of coal, by A. C. Fieldner. 1914. 59 pp., 6 figs.

TECHNICAL PAPER 98. Effect of low-temperature oxidation on the hydrogen in coal and the change of weight of coal in drying, by S. H. Katz and H. C. Porter. 1917. 16 pp., 2 figs.

TECHNICAL PAPER 113. Some properties of the water in coal, by H. C. Porter and O. C. Ralston. 1916. 30 pp., 3 figs.

TECHNICAL PAPER 133. Directions for sampling coal for shipment or delivery, by G. S. Pope. 1917. 15 pp., 1 pl.

TECHNICAL PAPER 140. The primary volatile products of the carbonization of coal; a sequel to Bulletin 1, The volatile matter of coal, by G. B. Taylor and H. C. Porter. 1916. 59 pp., 1 pl., 25 figs.

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DEPARTMENT OF THE INTERIOR
FRANKLIN K. LANE, SECRETARY
BUREAU OF MINES
VAN. H. MANNING, DIRECTOR

ABSTRACTS OF CURRENT DECISIONS
ON
MINES AND MINING

REPORTED FROM
OCTOBER TO DECEMBER, 1915

BY

J. W. THOMPSON

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PREFACE.

This bulletin is the sixth of its kind to be published by the Bureau of Mines, the five preceding being Bulletins 61, 79, 90, 101, and 113.

The wide demand for the information contained in these bulletins has led the bureau to decide to issue similar bulletins with sufficient frequency to keep reasonably current the records of decisions of Federal and State courts of last resort on questions relating to the mineral industry.

The bureau will gladly welcome and consider any suggestions looking to improvement in the matter contained in these bulletins or the manner in which it is presented. The purpose of the bulletins will continue to be to improve directly or indirectly mining conditions and to promote the health and safety of miners by the prompt publication of decisions, and to this end it is desired that the bulletins reach all persons who are interested.

VAN H. MANNING.

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ABSTRACTS OF CURRENT DECISIONS ON MINES AND MINING, OCTOBER TO DECEMBER, 1915.

By J. W. Thompson.

MINERALS AND MINERAL LANDS.

MINERALS.

CONTRACT OF SALE—CONSTRUCTION.

A contract stipulating for the delivery of quantities of phosphate rock "f. o. b. mines," and stipulating that "while this contract is in form an absolute sale for a fixed quantity in each year, it is mutually understood and agreed that the purchase is for the buyer's consumption and not for a sale; the buyer agreeing to give to seller the refusal of any surplus over and above the actual consumption. Buyer is at liberty to increase or diminish the quantity called for in any year, to the extent of not exceeding 10 per cent; provided that the quantity to be taken shall not be less than buyer's consumption; provided further that notice of such increased or diminished demand be given seller 12 months in advance of such change," is to be construed as a contract for the sale of stated quantities of rock, deliverable in approximately equal quantities during each year for the specified series of years, subject only to be increased or diminished after specified notice in any year, where the amount taken would not be less than the buyer's consumption, not exceeding 10 per cent, and the contract indicating that the rock was intended by both parties for consumption in the fertilizer plant of the buyer, but the quantity to be taken was not limited by the necessities of the plant.

Atlanta Oil & Fertilizer Co. v. Phosphate Mining Co. (Georgia), 86 Southeastern, 216, September, 1915.

DECREE QUIETING TITLE—EFFECT ON PERSONS NOT PARTIES.

A decree of court adjudicating and establishing title to mineral lands, "together with all the minerals thereon and therein contained," is in no way binding on persons who were not parties to the action in which the decree was rendered.

Demerse v. Mitchell (Michigan). 154 Northwestern, 22, p. 23, September, 1915.

PURCHASE INDUCED BY FRAUD—RIGHT TO RESCISSION.

A coal-mining company induced to purchase a coal lease together with property used in operating the mine is not entitled to a rescission of the contract on the ground of fraud where the bill for relief does not show that the property has been returned and does not offer to make restitution, or show sufficient reason for a failure so to do; or if it is impossible to restore the status quo and to put the seller in the condition existing before the contract was made, and in such case the remedy must be by abatement in price and not by rescission.

Consumers' Fuel & Coal Co. v. Yarbrough (Alabama), 69 Southern, 897, p. 900, October, 1915.

SALE AND CONVEYANCE.

CONTRACT OF SALE—FRAUD AND RESCISSION—RECOVERY OF MONEY PAID.

In an action by a purchaser of a mine to recover money paid by the purchaser to the seller upon a contract for the sale and purchase of the mine, where the plaintiff alleges that he was induced to agree to make the purchase by false and fraudulent representations made to him by the seller, to the effect that there was a certain vein in the mine at a certain place or level, and where the plaintiff had fully rescinded the contract before the commencement of the action, the defendant is not entitled to introduce evidence to prove the value of the mine, where there is no claim on the part of the defendant and no allegation in the plaintiff's complaint that the defendant either represented or misrepresented the value of the mine as a whole at the time of the alleged sale and purchase.

Cohen v. Stockton (California), 151 Pacific, 741, p. 742, August, 1915.

IMPLIED WARRANTY OF TITLE.

In the sale of a lease to mine the lands described therein, together with certain designated mining machinery and fixtures in the mine and other personal properties used in connection with the operation of the coal mined on the lands so leased, the law will imply a warranty of title, whether the vendor professed to be able to make a clear title, either by direct assertion to that effect or where he offers to make such a title by concealing the fact of his inability to do so, and his conduct in either case must be regarded as fraudulent, and if the property is encumbered by lien, the purchaser is entitled to his remedy by abatement in price.

Consumers' Fuel & Coal Co. v. Yarbrough (Alabama), 69 Southern, 897, p. 900, October, 1915.

PURCHASE OF LEASE INDUCED BY FRAUD—INJUNCTION.

A coal-mining company is entitled to a temporary injuction restraining a mortgagee from foreclosing his mortgage executed by it on the purchase of a mining lease, where the mortgagee induced the complainant to purchase the lease and execute its note and mortgage due in 18 months on the false and fraudulent representation of the mortgagee that he would cause all liens against the mining property to be satisfied, and fraudulently represented that certain bonds secured by a trust deed on the mining property matured in 18 months, the time the defendant's note and mortgage should mature, and that complainant could thereby protect itself, and where the defendant, as a further inducement to complainant to purchase the mining lease and execute to him its notes and mortgage, promised and agreed that the time on the note and mortgage held by him should in any event be extended until the date or after the date of the maturity of all indebtedness and liens against the mining property, and where it subsequently appeared that the bonds secured by the trust deed did not mature until two, three, and four years from the date of the note and mortgage executed by the complainant, and that the defendant refused to extend the time of the maturity thereof according to his promise, and was, in fact, proceeding to foreclose his mortgage by advertisement, the complainant is entitled, on the facts stated and the fraudulent representations contributing as an inducement to the execution of the note and mortgage maturing as they did, to a reformation of his note and mortgage in conformity with the defendant's promise of extension and an injunction restraining a premature foreclosure of such mortgage.

Consumers' Coal & Fuel Co. *v.* Yarbrough (Alabama), 69 Southern, 897, p. 899, October, 1915.

LAND HELD IN TRUST—DEATH OF TRUSTEES—RIGHT OF BENEFICIARY.

Where a deed for land was made to nine trustees for the benefit of a mining corporation, and where it appears that the trustees are all dead, the corporation may sue to have new trustees appointed in place of those whose names appear in the deed, and a court may grant such relief in order to prevent the failure of the trust, and the mining corporation may recover as against a wrongdoer on its equitable title.

Troy *v.* North Carolina Gold Mining Co. (North Carolina), 87 Southeastern, 40, p. 42, December, 1915.

SURFACE AND MINERALS—OWNERSHIP AND SEVERANCE.

RESERVATION OF MINERALS—ESTATES BY THE ENTIRETIES.

Where a wife has no interest other than an inchoate right of dower in mineral lands conveyed by deed in which she joins with her husband, and by which the minerals in the land were reserved to the

grantors, the presumption must be that she joined merely for the purpose of subjecting her dower, and the intention and effect of such a clause in a deed executed by the husband and wife is not to create in the minerals excepted any new right in the husband or wife, but to preserve in each the same rights each had therein before the execution of the deed; and if the estate was held by the entireties before the conveyance, no new estate by the entireties was created in the minerals by the reservation in the deed.

Demerse *v.* Mitchell (Michigan), 154 Northwestern, 22, p. 24, September, 1915.

COAL AND COAL LANDS.

RIGHT OF SURFACE OWNER TO DRILL ARTESIAN WELLS.

The owner of land who has conveyed to another the underlying coal is entitled to access to the strata beneath the coal, and on this principle the owner of the surface who has conveyed the coal has the right to sink an artesian well through the vein of coal for the purpose of obtaining water.

Pennsylvania Central Brewing Co. *v.* Lehigh Valley Coal Co. (Pennsylvania), 95 Atlantic, 471, July, 1915.

EMINENT DOMAIN—RIGHT OF WAY.

PIPE LINE—EASEMENT—RIGHT TO REPAIR.

The grant of an easement "to lay, maintain, operate, and remove" an oil and gas pipe line, the grantee to pay all damages that may accrue to the crops and fences, authorizes the grantee of the easement to enter on the right of way to make repairs and superadds no other liability, except for injuries resulting from the negligent or wanton exercise of the right thereby conferred; and the grant itself is competent evidence of the lawfulness of an entry thereunder and is admissible in evidence for such purpose.

Moore v. Hope Natural Gas Co. (West Virginia), 86 Southeastern, 564, September, 1915.

PIPE LINE—RECEIPT FOR DAMAGES.

A receipt and release by a landowner who had granted an easement to a natural gas company to lay and operate an oil and gas pipe line, the grantee to pay all damages to crops and fences, whereby the grantor acknowledged payment "in full for all damages on any and every account caused by or arising from laying, maintaining, and operating" such pipe line, does not when properly construed necessarily comprehend subsequent injuries and does not operate as a release, or accord any satisfaction for such subsequent injury, as the word "caused" is a perfect participle and imports acts already done, and the word "arising," while having a progressive and prospective meaning in some circumstances, usually signifies the present and generally denotes immediate present, and only occasionally implies future events or occurrences; and extrinsic evidence is admissible to show the circumstances surrounding parties at the date of the agreement or receipt, the nature of the transaction to which it was designed to apply, keeping in view the particular purposes to be effected, and giving to the terms employed their ordinary and usual meaning; but an accord and satisfaction does not operate as a bar as to matters unknown to the parties at the time of its execution.

Moore v. Hope Natural Gas Co. (West Virginia), 86 Southeastern, 564, p. 565, September, 1915.

PIPE LINE—INJURY TO CROPS AND FENCES.

Under a grant of an easement to lay and operate a pipe line, the grantee to pay all damages "to crops and fences," the term "crops,"

nothing appearing to the contrary, comprehends only such growths as are produced from the soil and severed or cropped by human instrumentalities, and it usually signifies and is generally understood to mean something cropped or severed from the land and garnered or saved by manual labor, as cereals, vegetables planted and cultivated, hay harvested from meadow land, corn grown and gathered in shocks, wheat in stacks or bins, or fodder and straw in shocks or ricks; but does not apply to grass on lands used for pasturage; and damages to crops, as so defined, is measured by their market value at the time and place of the injury, and a fence when readily repairable, is measured by the cost of material and labor, which will, when properly applied, restore the premises to their condition before the interference.

Moore v. Hope Natural Gas Co. (West Virginia), 86 Southeastern, 564, p. 567, September, 1915.

MINING TERMS.

BELL HOLES.

Bell holes are holes dug, or excavations made at the section joints of a pipe line for the purpose of repairs.

Moore *v.* Hope Natural Gas Co. (West Virginia), 86 Southeastern, 564, p. 565, September 1915.

MINING CORPORATIONS.

FRANCHISE TAX—UNCONSTITUTIONAL AS APPLIED TO RECEIVERS.

Under the constitution of Ohio the power of taxation of privileges and franchises is limited to the reasonable value of the privilege or franchise conferred originally or to its continued value from year to year; and these limitations prevent confiscation and oppression under the guise of taxation, and the power of such taxation can not extend beyond what is for the common or public welfare and the equal protection and benefit of the people; and where the property of a corporation has passed into the hands of a receiver and the corporation has ceased to do business, the franchise of such a corporation to be a corporation and to conduct its authorized business as such is of no value to the receiver and to the creditors whose property he holds and whom he represents, and the franchise tax imposed by the statutes of Ohio on such a receiver is, in its operation, confiscatory and oppressive, and to that extent unconstitutional.

Keeney *v.* Dominion Coal Co., 225 Federal, 625, p. 628.

FRANCHISE TAX—INSOLVENCY—FAILURE OF OFFICER TO DECLARE DISSOLUTION.

By section 5509 of the General Code of Ohio it is the mandatory duty of the secretary of state to cancel the articles of incorporation of a corporation that fails or neglects to make a report or to pay its franchise tax for 90 days after the statutory time, and thereupon its franchise would come to an end and the tax could not subsequently be imposed. And where a corporation becomes insolvent and passes into the hands of a receiver, the mere fact that the corporate officers did not begin proceedings for a dissolution does not enable the State to impose the franchise tax, where if the secretary of state had done his duty under the mandatory act the corporation would have been dissolved.

Keeney *v.* Dominion Coal Co. 225 Federal, 625, p. 629.

BANKRUPTCY—INSOLVENCY—PAYMENT AS A PREFERENCE.

Payments made by an insolvent mining corporation that amount to a preference constitute such acts of bankruptcy as will cause the corporation to be adjudged a bankrupt, where the corporation had reasonable cause to believe that the payments would effect a preference and such preferences are available.

Wise Coal Co. v. Small, 226 Federal, 524, p. 525.

BANKRUPTCY PROCEEDINGS—RIGHT OF STOCKHOLDERS TO INTERVENE.

In proceedings of creditors to have a mining corporation declared a bankrupt on the ground of the alleged indebtedness of the corporation to the petitioners, the stockholders of the corporation may intervene if the directors fraudulently fail and refuse to oppose the petition or interpose any defense, and where the petition to intervene shows that the directors are adversely interested and are permitting the property to be sold so that they may acquire it at less than its value; and in such case the stockholders are not required to take the ordinary preliminary steps before bringing suit.

Ogden v. Gilt Edge Consolidated Mines, 225 Federal, 723, p. 728.

PROPERTY IN HANDS OF RECEIVER ADMINISTERED FOR CREDITORS.

The assets of a corporation in the hands of a receiver do not belong to the corporation but to the creditors, and the court holds such assets for distribution to creditors as their respective interests may appear, under the rule that when a corporation becomes insolvent it is so far civilly dead that its property may be administered as a trust fund for the benefit of its stockholders and creditors.

Keeney v. Dominion Coal Co., 225 Federal, 625, p. 628.

CITIZENS' ORGANIZATION OF FOREIGN CORPORATION—COLLUSIVE JURISDICTION.

Citizens of California will not be permitted to organize a mining corporation in the State of Nevada and transfer to it the legal title to mining property in California for the purpose of conferring an apparent jurisdiction upon a Federal court on the ground of diversity of citizenship, which would not otherwise exist.

Phoenix-Buttes Gold Min. Co. v. Winstead, 226 Federal, 855, p. 861.
See Phoenix-Buttes Gold Min. Co. v. Winstead, 226 Federal, 863.

OFFICER EMPLOYED AS AGENT—DISCHARGE.

The president of an oil and gas company who was also employed as field manager is not as such field manager an officer of the company, but only an employee, and in the absence of an agreement for employment for a specified time he may be discharged as such field manager at any time.

Badger Oil & Gas Co. v. Preston (Oklahoma), 152 Pacific, 383, p. 385, October, 1915.

TRUST RELATION OF PRESIDENT AND CORPORATION—SECRET PROFITS.

The president of an oil and gas company who purchased stock from one of its stockholders for $250 and thereupon resold the stock to the corporation for $2,850 on the false and fraudulent representation to the corporation and to the board of directors that the stock cost him that particular sum, is liable to the corporation for the difference between the sum paid by him for the stock and the sum received by him for the stock from the corporation, as the president, as an officer of the corporation, occupies a fiduciary relation toward it, and can not, either directly or indirectly, in his dealings on behalf of the corporation, or in any transaction in which it is his duty to guard the interest of the corporation, make any secret profits or acquire any benefit or advantage not enjoyed by other stockholders.

Badger Oil & Gas Co. v. Preston (Oklahoma), 152 Pacific, 383, p. 385, October, 1915.

VALIDITY OF CONTRACT—INTERLOCKING DIRECTORS.

A contract between a smelting company and a mining company by the terms of which the smelting company agreed to erect a copper matte smelting plant with a certain stated daily capacity and agreed to pay or secure the extension of an indebtedness of the mining company and to make certain advances to the mining company to be used in repairs and preparations about its mines and property to fit it for the resumption of mining and production of ores, the advances to be repaid out of the first net proceeds of the ores of the mining company which should be treated by the smelting company, is not invalid because two of the members of the board of directors of the smelting company were members of the board of directors of the mining company, where there was no claim that the smelting company's control of the mining company's board of directors was obtained by undue, unfair, or fraudulent means, and where the note originally given as evidence of the advances and indebtedness was subsequently renewed by the board of directors of the mining company at a time when none of its members was a member of the board of directors of the smelting company.

Gould Copper Mining Co. v. Walker (Arizona), 152 Pacific, 853, p. 854, November, 1915.

RIGHT TO QUESTION CONSTITUTIONALITY OF STATUTE.

A mining corporation is not a "citizen" within the protection of the "privileges and immunities" provisions of the Federal Constitution, and such a corporation can not question the constitutionality of the workmen's compensation act on the ground that it effects a wrongful breachment of the privileges and immunities of citizenship.

Hunter v. Colfax Consolidated Coal Co. (Iowa), 154 Northwestern, 1037, p. 1067, November, 1915.

INSOLVENCY—RIGHT OF BONDHOLDERS TO PRIORITY.

The owners of land who sold the same for a stated price to a mining corporation and received in payment therefor a part of an issue of bonds of the corporation at 80 cents on the dollar, which showed on their face a total issue of $100,000, and who accepted and held such bonds and received the interest thereon for two years, can not on the subsequent insolvency of the corporation maintain an action to have their deed to the land canceled and set aside on the ground of fraud on the part of the corporation in making an excessive issue of bonds, and thereby acquire a priority over other bondholders and creditors, but their rights under such circumstances are upon the bonds and their rights and remedies the same as other bondholders.

Yellow Chief Coal Co. *v.* Johnson (Kentucky), 179 Southwestern, 599, p. 601, November, 1915.

AUTHORITY OF OIL COMPANY TO OWN RAILROAD.

Under the amendatory statute of Texas a corporation formed for the establishment and maintenance of oil companies with the authority to contract for the lease and purchase of the right to prospect for, develop, and use coal and other minerals, petroleum and gas, and with the right to erect, build, and own the necessary oil tanks, cars, and pipes necessary for the operation of the business of the same, and giving corporations theretofore created similar rights, does not authorize a producing oil company organized in another State to own and operate a railroad to be used in connection with its business, nor does it authorize such a corporation through a receiver to operate a railroad.

Continental Trust Co. *v.* Brown (Texas Civil Appeals), 179 Southwestern, 939, p. 943, November, 1915.

MISTAKE IN NAME OF CORPORATION.

A corporation can legally have but one name and that must be the name given it in its articles of incorporation, and in that name it is authorized to do business and maintain suits, and when sued it should be sued by such name. But where an injured miner brought suit against the Imperial Coal Company charging it with negligence causing the injury complained of, when as a matter of fact the complainant at the time of his injury was an employee of the "Imperial Jellico Coal Company" and his cause of action was against that company and not against the Imperial Coal Company; and though summons on the petition against the Imperial Coal Company was executed on an authorized agent of the Imperial Jellico Coal Company, this furnished no aid in correcting the mistake of the complainant, as the Imperial Jellico Coal Company was not sued and was not before the court; but the mere omission from the petition of the word "Jellico" was not, in view of the admitted fact that

the Imperial Jellico Coal Company was the name of the corporation for which the complainant was working at the time of his injury, and the name of the corporation which he intended to sue, such a substantial omission or mistake as to affect the sufficiency of the petition as the commencement of an action against the Imperial Jellico Coal Company and the error is immaterial under the code pleading, and an amendment inserting the word "Jellico" subsequently filed relates back to and becomes a part of the original petition.

Imperial Jellico Coal Co. v. New (Kentucky); 179 Southwestern, 329, p. 330, November, 1915.

CONVEYANCE TO TRUSTEES—EFFECT.

A deed of land to nine persons named as trustees of a mining corporation does in effect convey the land to the trustees for the mining corporation and not to such trustees for their own benefit.

Troy v. North Carolina Gold Mining Co. (North Carolina), 87 Southeastern, 40, p 41, December, 1915.

DISSOLUTION ON ORDER OF COURT.

A mining corporation is properly dissolved by a court on application of a stockholder where by reason of the gross mismanagement of its affairs it was in imminent danger of insolvency and danger that the estate and effects would be wasted, and because it had ceased to do business.

Murphy v. Utah Mining, Milling & Transportation Co. (Maine), 95 Atlantic, 887, p. 888, December, 1915.

SALE OF PROPERTY—APPOINTMENT OF RECEIVER.

Where a corporation organized for the purpose of operating mining claims owned by it, sold and transferred all its mining claims and where it has ceased to do business and its property is liable to be wasted, a receiver is properly appointed to wind up the corporation.

Murphy v. Utah Mining, Milling & Transportation Co. (Maine), 95 Atlantic, 887, p. 888, December, 1915.

MINING CLAIMS.

GENERAL FEATURES.

INSPECTION BY LAND OFFICERS—RIGHT OF LOCATOR TO INJUNCTION.

Where a register and receiver of a local land office have been ordered and directed by the Secretary of the Interior to examine and determine whether the land embraced within the boundaries of an unpatented mining claim is mineral or nonmineral, and whether or not a discovery of mineral bearing vein has been made with reference to lode and placer locations, and whether or not any such location has been made in good faith for mineral purposes or for speculative purposes and to be used in connection with trade and business, and where such register and receiver are proceeding to carry out such orders, a court has no jurisdiction to restrain such register and receiver from executing such orders of the Secretary of the Interior.

Cameron *v.* Weedin, 226 Federal, 44.

JURISDICTION OF LAND DEPARTMENT TO DETERMINE MINERAL CHARACTER.

The General Land Office is without jurisdiction to inspect and examine an unpatented mining claim, in the absence of an application for patent, to determine whether the land embraced within the boundaries is mineral or nonmineral, or whether a discovery of a mineral-bearing vein has been made, and whether or not the location has been made in good faith for mineral purposes.

Cameron *v.* Weedin, 226 Federal, 44, p. 48.

POSSESSORY RIGHTS.

ACTION TO QUIET TITLE.

Where an application for patent was filed for a group of mining claims, and an adverse claim was filed by which the adverse claimant asserted title to one of the group of claims, and where it was agreed that the applicant would not claim or obtain patent for such particular claim, and the adverse claim was withdrawn and the suit brought thereon dismissed, and where on failure to comply with the agreement the applicant claimed patent for all the claims in the group, and there-

upon the adverse claimant brought a separate action alleging generally the facts and history, such action was in its nature and under the averments of the petition of the complaint an action to quiet title and not an application to acquire a patent from the United States to the particular claim in controversy, nor was it a suit upon the adverse claim, and the plaintiff under the allegations of his pleading was entitled to be heard and have his rights determined.

Poncia *v.* Eagle (Idaho), 152 Pacific, 208, p. 209, October, 1915.

INVALID LOCATION—LOCATOR'S RIGHT AS AGAINST STRANGER.

The title of a locator under a mining location merely without discovery of minerals is totally invalid and of no effect only in a qualified sense, as such title by a location and possession is good as against every person contending against it, except the paramount owner, the Government of the United States. The possession of a person making such a location with the view of making a discovery of oil can not have such possession disturbed by strangers.

Hullinger *v.* Big Sespe Oil Co. (California), 151 Pacific, 369, August, 1915.

STATUTES RELATING TO MINING OPERATIONS.

CONSTRUCTION, VALIDITY, AND EFFECT.

LEGISLATIVE POWER—REGULATING COAL MINING.

The legislature of a State has power to pass laws regulating an extra hazardous business, such as coal mining, and to provide for benefits in case of injury or death, upon the ground that it involves an intention to reduce economic waste, to obviate breaches and dissensions between employers and employees, to raise the standard of citizenship, to lower the general burden of taxation, and to promote peace, order, and morals, as well as upon the ground that such an act is the proper exercise of the police power.

Hunter *v.* Colfax Consolidated Coal Co. (Iowa), 154 Northwestern, 1037, p. 1051, November, 1915.
See Cunningham *v.* Northwestern Improvement Co., 44 Montana, 180, 119 Pacific, 554.

MINERS' COMPENSATION ACT.

A law known as a miners' compensation act is held valid though it provides a summary method for the disposition of claims filed under the law, and such an act is not unconstitutional as conferring judicial power on a State officer having charge and oversight of its administration.

Hunter *v.* Colfax Consolidated Coal Co. (Iowa), 154 Northwestern, 1037, p. 1061, November, 1915.
See Cunningham *v.* Northwestern Improvement Co., 44 Montana, 180, 119 Pacific, 554.

WORKMEN'S COMPENSATION LAW.

The West Virginia workmen's compensation act is such a statute as it is in the power of the legislature to pass. The act does not make an employer liable except in cases of his own direct or indirect negligence or wrongful act, and the defenses of contributory negligence and assumption of risk which are inhibited or barred are such as the legislature has a clear right to eliminate for reasons of public policy.

De Francesco *v.* Piney Mining Co. (West Virginia), 86 Southeastern, 777, p. 778, October, 1915.

EFFECT ON RIGHT TO CONTRACT.

The Iowa workmen's compensation act as applied to mining and other corporations prohibits any contract, rule, or regulation that

shall operate to relieve an employer from any liability created by the act, except as the act itself provides; and it makes any device by which the employee is to pay an insurance premium against the compensation provided in the act null and void, and permits no wages to be withheld for the purpose of paying premiums, and prevents an employee from waiving any provisions of the act if the statutory compensation is thereby lessened. But another section provides that the fixed amount of compensation can not be reduced by contribution from employees. These are, however, in essence, guards against contracts to reduce liability for negligence; and instead of being an invasion of the right of contract they are precautions against allowing an employer to first accept the act and then avoid it by subterfuge, and thus what is taken away is not the right to bargain, but the right, by deviousness, to break the bargain made, and aside from this the right to contract is not infringed by the provisions aimed to insure compliance with contracts entered into.

Hunter .. Colfax Consolidated Coal Co (Iowa), 154 Northwestern 1037, p. 1049. November, 1915.

CONTRACTS TO THE DISADVANTAGE OF THE EMPLOYEE PROHIBITED—EFFECT ON VALIDITY.

The provision of section 3 of the Iowa workmen's compensation act as to the presumption arising when an employee rejects the benefit of the act and the provision of section 19 as to the presumption of fraud in a contract of settlement made by an injured miner can not be said to interfere with the right to contract, as the legislature having power to enact a valid compensation act always has power to make provisions against having the legislative intent as to such act thwarted, and to put the ban on such influences interferes with no right of contract, but simply heads off methods of evading and crippling the act. One underlying purpose of the act is to promote acceptance by the employee of the benefits of the act, and the provision of section 19 is an attempt to prevent fraud in dealing with an injured employee and is intended to guard against the nullification of the act through the employer's obtaining a contract to the disadvantage of the employee when he may be physically and financially in distress; but the act does not in fact prevent or make void the contract, but only makes it presumptively fraudulent, merely changing the burden of proof as to the validity of such contracts.

Hunter v. Colfax Consolidated Coal Co (Iowa). 154 Northwestern, 1037, p 1050, November, 1915.

LIMITING POWER TO CONTRACT.

A statute preventing miners employed at quantity rates from contracting for wages upon the basis of screened coal, instead of the

weight of the coal as originally produced in the mine, is not invalid and unconstitutional because it limits or deprives persons of the right to contract.

Hunter v. Colfax Consolidated Coal Co. (Iowa), 154 Northwestern, 1037, p. 1051, November, 1915.

CLASSIFICATION AS TO MINING.

The workmen's compensation act of Iowa is not unconstitutional on the ground of class legislation and because it applies to coal mining and excepts from its operation domestic servants, farm or other laborers engaged in agricultural pursuits, and persons whose employment is of a casual nature, and those engaged in clerical labor, as the differentiation between coal mining and some or all of such excepted persons is not arbitrary but natural and justified, and strict equality is neither necessary nor practically obtainable; and accordingly the act is not subject to the charge of class legislation.

Hunter v. Colfax Consolidated Coal Co (Iowa), 154 Northwestern, 1037, p. 1052, November, 1915

OUSTING JURISDICTION OF COURT.

The Iowa workmen's compensation act is not invalid on the ground that it ousts the courts of all jurisdiction to try controversies between employers and employees. Even if it did this, the acceptance of the act is elective and when rejected the full dispute between the parties may be submitted to a court by ordinary proceedings and tried in the usual manner; and while some rules of procedure are changed, some defenses are eliminated, and there is some change in the burden of proof, yet the objection is not sustained that on rejection of the act the courts no longer have jurisdiction to try suits for injury to an employee. It is true that when the statute is accepted it does operate to take from the courts so much of the controversy as is determined by applying the statutory schedules through the agency of the statutory arbitrators; but it does not constitute an agreement for complete ouster of jurisdiction of the courts to provide by contract for the arbitration of special matters, leaving ultimate liability or nonliability to be settled by the courts. But the very basis of power to award compensation under the act is that its provisions must first be accepted and that the claimant must be an employee and that he must have sustained personal injuries arising out of and in the course of the employment and that the compensation shall be at rates fixed by the statute; and arbitration is provided for only when the employer and employee fail to reach an agreement in regard to compensation under the act. The utmost the statute does is to provide administrative machinery for applying rates of compensation fixed by the legislature as between the parties who have agreed to have the amount of compensation thus determined.

Hunter v. Colfax Consolidated Coal Co. (Iowa), 154 Northwestern, 1037, p. 1063, November, 1915.

IOWA COMPENSATION ACT—DEFENSES TAKEN AWAY.

The workmen's compensation act of Iowa (Acts of 35th General Assembly, chap. 147) takes from the employer, if he accepts the provisions of the act, the following defenses: (1) That the employee assumed the risks inherent in, or incident to, or arising out of the employment; (2) that the employee assumed the risks arising from the failure of the employer to provide and maintain a reasonably safe place for the employee to work; (3) that the employee assumed the risks arising from the failure of the employer to furnish reasonably safe tools and appliances; (4) that the employer exercised reasonable care in selecting reasonably competent employees; and (5) that the injury was caused by the negligence of a fellow servant or coemployee.

Hunter v. Colfax Consolidated Coal Co. (Iowa), 154 Northwestern, 1037, p. 1040, November, 1915

PRESUMPTION AS TO NEGLIGENCE—BURDEN OF PROOF.

The workmen's compensation act of Iowa provides that in case of injury to an employee it shall be presumed: (1) That the injury was the direct result and grew out of the negligence of the employer; (2) that such negligence was the proximate cause of the injury, and in such case the burden of proof shall rest upon the employer to rebut the presumption of negligence. But this does not deprive the employer of the right to show he was wholly free from blame, but casts upon him the affirmative of showing that he is blameless, and in effect says that the employee need not prove the employer was at fault, but the latter must show that he was free from fault.

Hunter v. Colfax Consolidated Coal Co. (Iowa), 154 Northwestern, 1037, p. 1041, November, 1915.

LIABILITY IN ABSENCE OF NEGLIGENCE.

A law that attempts to make a mining company or other corporation liable for accidents which were not caused by its negligence, or by its disobedience of some law, but caused by the negligence of others, or by uncontrollable causes, or that does not give the mining company or corporation an opportunity to show such facts in its own defense, is void.

Hunter v. Colfax Consolidated Coal Co. (Iowa), 154 Northwestern, 1037, p. 1046, November, 1915.

BURDEN TO SHOW FREEDOM FROM NEGLIGENCE.

The Iowa workmen's compensation act provides that the only negligence of an injured employee which is available as a complete defense is negligence which is self-inflicted or injury which is the result of intoxication; but the employer is at liberty to prove that, either by reason of the negligence of the plaintiff, or for any other reason, he was

wholly free from fault. While under the act it was to be presumed that the proximate injury of the employee was the direct result of negligence on the part of the employer, and the burden of proof is cast upon the employer to rebut this presumption, and to show affirmatively that no negligence of his caused the injury, the rules as to presumptions and burden of proof are court made and can be changed or abrogated by the legislature; and if the court could place the burden on the injured employee to prove his freedom from contributory negligence, the legislature may abolish this rule and place the burden upon the employer to show that he was not negligent.

Hunter v. Colfax Consolidated Coal Co. (Iowa), 154 Northwestern, 1037, p. 1065, November, 1915.

INDUCING MINER TO REJECT BENEFIT OF STATUTE—EFFECT.

Section 3 of the Iowa workmen's compensation act provides that if by or on behalf of the employer any request, suggestion, or demand was made that an employee, or a person seeking employment, shall exercise his right to reject the act, there shall arise a conclusive presumption that such employee or applicant was unduly influenced to exercise this right and that the rejection made under such circumstances shall be conclusively presumed to have been procured through fraud and be null and void.

Hunter v. Colfax Consolidated Coal Co. (Iowa), 154 Northwestern, 1037, p. 1050, November, 1915.

ACCEPTANCE OF WORKMEN'S COMPENSATION ACT NOT COMPULSORY.

The Iowa workmen's compensation act is not subject to the charge of unconstitutionality on the ground that it compels an employer to accept its provisions and then deprives him of certain rights. The statute does not compel acceptance, but it does provide that the presumption that the employer has elected to accept its provisions prevails unless certain prescribed notices are given by him; but this does not compel him to accept the act, but is merely a provision as to what he must do to avoid a presumption that he has accepted it; and the claim is wholly immaterial where a complaining corporation concedes that it has rejected the provisions of the statute.

Hunter v. Colfax Consolidated Coal Co. (Iowa), 154 Northwestern, 1037, p. 1068, November, 1915.

RIGHT TO QUESTION VALIDITY OF STATUTE.

An attack upon the constitutionality of the Iowa workmen's compensation law by a mine operator will not be justified or permitted on the ground that it may be so construed as to invade private rights secured by the constitution, unless such mining corporation shows that in the case it presents the effect of applying the statute is to deprive it of a constitutional right. But if acceptance of the act is elective, then the claim of its invading constitutional rights will fail.

Hunter v. Colfax Consolidated Coal Co. (Iowa) 154 Northwestern, 1037, p. 1048, November 1915.

TRIAL BY JURY LIMITED BUT NOT DENIED.

The Iowa workmen's compensation act does not accomplish a denial of the right of trial by a jury, particularly in cases where the employer rejects the compensation statute; and the fact that the statute accomplishes giving the jury less to do than formerly, and changes the character of its work, in that a jury will no longer consider whether the employeee should be defeated because the evidence shows he assumed the risk of being injured as he was and can not consider the question as to whether the alleged injury was due to the negligence of a fellow servant nor whether the injured employee has proved that his injury is due to the negligence of the employer, but begins its inquiries by assuming the employer was negligent and then considers whether the employer has proved, notwithstanding this presumption, that he was wholly free from fault, does not amount to a denial of a trial by jury but merely changes the rules under which such trial shall proceed.

Hunter v. Colfax Consolidated Coal Co. (Iowa), 154 Northwestern, 1037, p. 1066, November, 1915.

CONSTRUCTION OF STATUTE—SPACE AT SIDE OF TRACKWAY.

Section 8582, Burns' Statutes of Indiana, makes it unlawful for an owner or operator of a coal mine to construct an entry or trackway in a coal mine without a space of at least 3 feet on one or both sides, so that drivers may get away from the car and track in event of collision, wreck, or accident; and the term entry or trackway applies to a place where a track is laid rather than to the track itself, and was intended to give sufficient room to provide a safe place for the car drivers in case of an accident, and the failure of an operator or owner to furnish such space may be the proximate cause of an injury to a driver injured after an accident produced by other causes, where he is unable to escape by reason of the operator's noncompliance.

Elder v. Erie Canal Coal Co. (Indiana Appellate), 109 Northeastern, 805, p. 806, October, 1915.

DUTIES IMPOSED ON OPERATOR.

FAILURE TO CONSTRUCT SHELTER HOLES—KNOWLEDGE OF CONDITION.

Under the statute of Pennsylvania the responsibility for the care of passageways in a mine rests upon the owner, and the fact that the owner has placed in the mine a competent certified mine foreman does not relieve the owner from the liability imposed by the statute. The duty to provide a proper passageway in a tunnel in a mine is a nondelegable duty imposed upon the mine owner and is not a statutory duty imposed upon the mine foreman. While the statute makes it the duty of a mine foreman to see that shelter holes are cut along

main hauling roads in a bituminous coal mine, yet this does not relieve the owner from liability for injury to a miner resulting from his failure to comply with such provision, and where such owner has knowledge that the requirement has not been complied with.

Barnes & Tucker Coal Co. v. Vosar, 227 Federal, 25, p. 29.

DUTY OF OPERATOR TO FURNISH PROPS—CUSTOM AS TO PROPPING ROOF.

Under the Kentucky statute of 1913 and before the amendments of 1914 it was the duty of a mine owner, after a miner had selected and marked them, to furnish to the miner a sufficient number of caps and props to be used by him in securing the roof in his room, and at such other working places where by law or custom of those usually engaged in such employment it was the duty of the miners to keep the roof propped; but this statute does not apply where, by custom or rule of the mine, the duty of propping or timbering does not devolve upon the miner himself, and where an injured miner in an action for damages shows that under the custom of the mine no duty of propping devolved upon him.

Carter Coal Co. v. Hill (Kentucky), 179 Southwestern, 2, p. 4, October, 1915.

SAFETY APPLIANCES—APPLICATION TO UNFINISHED MINES.

Section 28 of the Tennessee act of 1903 requires that the bucket shall be covered and there shall be certain structures inside of the shaft to make safe the ascent and descent of the miner, and this act applies to a mine incomplete. Thus where a shaft had been sunk to a depth of more than 250 feet, from the foot of which a drift was run to the location of an old shaft on the property with a view to drilling upward and reaching the bottom of such old shaft and thus connecting the two, and where men were taken up and down the new shaft for the purpose of working in the incompleted mine, and in such condition and in so using the shaft there was as much need to the miners of the protection required by the statute as there could be when the mine was completed and in active operation. The miners in thus using the shaft and in being lowered and raised in the bucket did not assume the risk of the operator's failure to comply with the statute, for the reason that to hold that miners did assume the risk would be equivalent to a repeal of the statute, as this would be a continuing invitation for the operator to forbear compliance with the statutory provision, and the very purpose of the statute was to protect those who were unable to protect themselves, occupying, as the miners necessarily do, a position much inferior in financial security to that of the mine operator.

American Zinc Co. v. Graham (Tennessee), 179 Southwestern 138 p. 139, October, 1915.

VIOLATION OF DUTY AS NEGLIGENCE PER SE.

The violation by a mine operator of the terms of the statute of Tennessee (Laws 1903, ch. 237, sec. 28) requiring certain structures to secure safety in mine shafts is negligence per se and renders the operator guilty of such conduct responsible for all injuries which may be suffered as a direct consequence thereof.

American Zinc Co. v. Graham (Tennessee), 179 Southwestern, 138, p. 139, October, 1915.

OPERATOR'S FAILURE TO ACCEPT WORKMEN'S COMPENSATION ACT.

The Iowa workmen's compensation act provides that where both the employer and employee reject its provisions the liability of the employer shall be the same as though the employee had not rejected it; but it contains another provision to the effect that if the employee rejects he must suffer, in his suit for damages for injuries, the employer's right to plead and rely upon any and all defenses, including those at common law, and the rules and defenses of contributory negligence and assumption of risk and fellow servant, with perhaps certain limitations; and it is further provided that compensation under the act is to be awarded only if both have done what amounts to acceptance of the act. Construed as a whole, the act does penalize the employee who rejects it, and while the penalties imposed upon the employer and employee may not be precisely the same, yet this is not vital and does not sustain a broad charge that an arbitrary difference is created as to the consequences of conduct which is, in substance, alike. But were it otherwise the police power may be invoked to sustain some differentiations in favor of the employee, on the theory that this is a method of protecting him for the public good against the actual inequality between him and his employer.

Hunter v. Colfax Consolidated Coal Co. (Iowa), 154 Northwestern, 1037, p. 1053, November, 1915.

DUTY TO INSULATE CABLE—LIABILITY FOR BREACH OF DUTY.

The fact that a mine owner failed to keep a cable properly insulated was a violation of the statute and was negligence per se, and while the rule might apply though the cable was operated in an unused air course, being but a rough passageway for the circulation of outer air and used only as a conduit for the cable, yet the mine owner's violation of the statute would be a breach of duty only to those persons who were, when injured thereby, rightfully present at the place of contact and danger and in the exercise of their legal rights.

Patterson v. Alabama Fuel & Iron Co. (Alabama), 69 Southern, 952, p. 954, November, 1915.

PROVIDING PLACE FOR STORING POWDER.

The statutes of Alabama (Gen. Sess. Acts, 1911, p. 530, secs. 84 and 85), require that powder in mines shall be kept in locked wooden boxes not nearer than 100 feet to any working place; and a

mine owner who prepares and keeps a proper box at the required distance for the use of a miner can not be held liable for the death of a miner who, without the knowledge or consent of the mine owner, kept and stored his powder in a different and dangerous place in the mine.

Patterson v. Alabama Fuel & Iron Co. (Alabama), 69 Southern, 952, p. 954, November, 1915.

DUTY TO INSTRUCT INEXPERIENCED MINER—EXTENT AND APPLICATION OF DOCTRINE.

Neither the statute of West Virginia nor the common law requires a master to instruct a miner as to dangers of which he has knowledge or as to means of avoidance fully known to him; but the statutory requirement proceeds upon the theory of lack of knowledge in the employee as it applies only to inexperienced miners. The common law imposes no duty to instruct a servant of full age and average intelligence as to elements of danger that are obvious to persons of his class, and a mine operator is under no duty to instruct as to acts and things commonly known to be dangerous. To exact such a duty, under the statute abrogating assumption of risk and contributory negligence, would be violative of the letter and spirit of that portion thereof which imposes liability only for negligence or other wrongful act causing injury and would make the employer a guarantor of the safety of the employee from the consequence of his own careless acts.

De Francesco v. Piney Mining Co. (West Virginia), 86 Southeastern, 777, p. 779, October, 1915.

DUTY TO FURNISH PROPS—STATUTORY ACTION NOT EXCLUSIVE.

Whether a petition in an action for the death of a miner caused by a fall of rock from the roof states a cause of action will not be determined by the provisions of section 8473, Missouri Revised Statutes of 1909, relating to the duty of a coal-mine operator to furnish props when requested, as the remedy given by this section is not exclusive, where it appears that the petition is based on the common-law liability.

Atwell v. Marceline Coal & Mining Co. (Missouri Appeals), 180 Southwestern, 400, p. 401, November, 1915.

DUTIES IMPOSED ON MINER.

MINER'S DUTY TO KEEP OUT OF DANGEROUS PLACE.

There can be no recovery for the death of a miner under the Virginia mining act of 1912 where the evidence shows that the deceased miner violated the statute in not staying out of the place where he was killed until he got sufficient props to make the place safe and violated the statute in undertaking to work in a place before he had made it safe.

Virginia Iron, Coal & Coke Co v. Asbury (Virginia), 86 Southeastern, 148, p. 151, September, 1915.
Huettel Coal & Coke Co. v. Lawrence (Virginia), 86 Southeastern, 151, September, 1915.

NEGLIGENCE OF MINE SUPERINTENDENT OR FOREMAN.

OPERATOR NOT LIABLE FOR NEGLIGENCE OF MINE FOREMAN.

The bituminous mining act of Pennsylvania of 1911 places the management of the inner workings of bituminous coal mines in the hands of a certified mine foreman, and neither he nor his assistants whom he appoints are agents of the mining company and the company is not responsible for their acts unless it has notice that an emergency or danger has arisen demanding immediate action and that the mine foreman and his assistants are not discharging their duties with regard thereto; but the mining company is responsible if it has failed to comply with the orders of the mine foreman.

Vagaszki v. Consolidated Coal Co., 225 Federal, 913, p. 915.

KNOWLEDGE OF DANGEROUS CONDITIONS—OPERATOR LIABLE FOR FOREMAN'S NEGLIGENCE.

The Pennsylvania mining act of 1891 does not relieve a mine operator from liability for his own neglect or failure of duty; and if through any neglect or failure of duty he causes injury to one of his employees the general rule applicable in such cases subjects the owner to damages for such default, and if there is a dangerous condition existing in the mine which is permitted by the negligence of a mine foreman resulting in injury to an employee, the mine owner will be responsible if he has knowledge of the fact and takes no steps to remove it, as the owner can not neglect his duty and escape liability, and the statute expressly provides that the owner shall use every precaution to insure the safety of the workmen in all cases whether provided for in the act or not.

McCollom v. Pennsylvania Coal Co. (Pennsylvania), 95 Atlantic, 380, p. 381, May, 1915.

KNOWLEDGE OF NEGLIGENCE OF MINE FOREMAN.

When a mine owner has knowledge of conditions in a mine which are hazardous to employees, or has knowledge of the failure of the mine foreman to properly perform his duty in safeguarding the lives of the miners, it is the operator's duty to remedy such dangerous condition; and a failure on his part to do so will give rise to liability which he can not avoid by a pleading that the danger arose through the act of the mine foreman, for whose negligence he is not responsible.

McCollom v. Pennsylvania Coal Co. (Pennsylvania), 95 Atlantic, 380, p. 381, May, 1915.

FAILURE OF OWNER TO PROVIDE ALARM FOR CARS—LIABILITY FOR NEGLIGENCE OF FOREMAN.

Rule 44 of the act of 1891 of Pennsylvania requires an efficient alarm to be provided and attached to the front end of every train of cars operated by locomotive in any mine or part of a mine; and this

applies not only to the main roadway of the mine, but extends to every siding in every heading of the mine; and the duty to provide the alarm is one which in its very nature devolves upon the mine owner in so far as providing the alarm is concerned, and the failure or the negligence of a mine foreman to perform this duty, if known to the operator, or if it had continued for so long a period that it should have been known to the operator or owner, will render him liable for injuries resulting from either his own or the foreman's negligence in this respect.

McCollom *v.* Pennsylvania Coal Co. (Pennsylvania), 95 Atlantic, 330, p. 331, May, 1915.

WORKMEN'S COMPENSATION ACT—EFFECT ON NEGLIGENCE OF STATUTORY MINE FOREMAN.

Section 26 of chapter 15 (Code Sec. 476) of the workmen's compensation act of West Virginia makes it the duty of a mine foreman or his assistant to see that every person employed to work in a mine shall before beginning work be instructed as to the particular danger incident to his work in the mine, and requires every inexperienced person to work under the direction of the mine foreman or some other experienced worker designated until he is familiar with the danger incident to his work. Under the law as it was before the enactment of the workmen's compensation act the mine operator was not liable for the result of the nonperformance of this duty, as the mine foreman was regarded as a fellow servant whose negligent acts were governed by the fellow-servant rule. But section 26 of the workmen's compensation act specifically takes away this right of defense and provides that an employer who neglects to take the benefit of the act "shall not avail himself of any defense that the negligence in question was that of some one whose duties are prescribed by statute." The effect of this provision, read in connection with another provision of the same section making the employer liable for the wrongful act, neglect, or default of any of his officers, agents, or employees, is to make the mine foreman virtually a vice principal.

De Francesco *v.* Piney Mining Co. (West Virginia), 86 Southeastern, 777, p. 778, October, 1915.

LIABILITY FOR NEGLIGENCE OF BANK BOSS.

A recovery for an injury to a miner is sufficiently sustained where the miner went into his room either at the direction or with the knowledge and consent of the bank boss, and where there was evidence from which the jury could infer that such bank boss knew of the existence of gas in the room, or negligently failed to ascertain the fact before ordering or permitting the miner to enter the room.

Woodward Iron Co. *v.* Lowther (Alabama), 69 Southern, 877, p. 878, October, 1915.

KNOWLEDGE OF DANGEROUS CONDITION—JOINT LIABILITY FOR INJURIES TO MINERS.

The mining act of Pennsylvania does not relieve the owner or operator from liability for his own neglect or failure of duty, and there may be cases in which both the mine foreman and the mine owner may be liable to an injured miner. Thus, if through any neglect or failure of duty the mine owner causes an injury to one of his employees, the general rule applicable in such case subjects the owner to damages for such default; or, if there is a dangerous condition existing in the mine which is permitted by the negligence of the mine foreman, resulting in injury to an employee, the mine owner will be responsible if he has knowledge of the fact and takes no steps to remove such dangerous condition, as the owner can not neglect this duty and escape responsibility, as the statute requires the owner to use every precaution to insure the safety of the workmen in all cases, whether provided for in the statute or not.

Barnes & Tucker Coal Co. v. Vozar, 227 Federal, 25, p. 29.

EFFECT ON CONTRIBUTORY NEGLIGENCE.

CONTRIBUTORY NEGLIGENCE OF MINER—VIOLATION OF STATUTORY DUTY.

The purpose of the Virginia statute of 1912, known as the Mining Act, was to promote the safety of miners and was not intended to relieve employees or miners in mining operations from exercising that degree of care and diligence for their own safety which the law required prior to the enactment, as it expressly provides that it shall be the duty of each miner to properly prop and secure his place in order to make the same secure for him to work therein, and prohibits a miner from working unless he has props and timbers sufficient to make the place secure, and if a miner's place becomes dangerous and is known so to him he is guilty of contributory negligence in not leaving his working place until sufficient props arrive to make the place secure, and the statute imposes the duty on him to leave his working place as soon as it becomes insecure from lack of props as well as upon the operator to furnish props, and the violation of this statutory duty by a miner will preclude a recovery either for an injury or death.

Virginia Iron, Coal & Coke Co. v. Asbury (Virginia), 86 Southeastern, 148, p. 149, September, 1915.

STATUTE ABOLISHING ASSUMPTION OF RISK.

Where a miner is guilty of contributory negligence which was the proximate cause of his death, it is wholly immaterial, so far as the instant case is concerned, whether the doctrine of assumed risk is abolished by the statute or not.

Virginia Iron, Coal & Coke Co. v. Asbury (Virginia), 86 Southeastern, 148, p. 151, September, 1915.

SUFFICIENCY OF ANSWER OF CONTRIBUTORY NEGLIGENCE AGAINST GENERAL CHARGE OF NEGLIGENCE.

In an action for the death of a miner caused by a fall of slate from the roof because of the negligence of certain employees who were entrusted with superintendence, under the statute of Alabama, an answer is sufficient which shows that the negligence of the intestate concurred with that of the employer to produce the negligence based upon the breach of duty on the part of the intestate to safely prop the roof of the mine at the dangerous place, or the failure to pull down loose slate or rock from the roof, or a failure to keep the roof in good condition, in allowing slate or loose rock to remain in the roof which should have been removed, or a failure to inspect the roof, as these acts constitute a good defense as against a general charge of negligence on the part of the defendant in failing to provide the intestate with a reasonably safe place in which to perform the duties of his employment.

Standard Steel Co. v. Clifton (Alabama), 69 Southern, 937, p. 938, October, 1915.

CONTRIBUTORY NEGLIGENCE AS PROXIMATE CAUSE OF DEATH—DEFENSE.

In an action for the death of a miner on the ground that the mine operator negligently failed to provide the miner with a reasonably safe place in which to perform the duties of employment, answers are sufficient where they show that the deceased miner was negligent and that such negligence proximately contributed to his death, as the effect of the statute is to make the mine operator liable to answer in damages to a miner the same as if he were a stranger and not engaged in the service or employment, and accordingly, if the intestate had been a stranger, and had been guilty of contributory negligence which proximately contributed to his death, this would have been a defense to the action stated, and must under the theory of the statute be a defense in an action for the death of the miner.

Standard Steel Co. v. Clifton (Alabama), 69 Southern, 937, p. 939, October, 1915.

DEFENSE OF CONTRIBUTORY NEGLIGENCE ABOLISHED.

The Iowa workmen's compensation act abolishes the doctrine that an injured miner can not recover because of contributory negligence on his part, however slight, though the negligence of the operator may be great or gross. But the statute has in fact added to the defense of contributory negligence rather than subtracted from it, and but for this statute all contributory negligence would be available in mitigation of damages, and under this statute there is a right to plead it in mitigation, plus the right to plead some contributory negligence in bar, and recovery may be defeated by showing the employee's willful

intention to injure himself or where the intoxication of the employee was the proximate cause of the injury. But in any event the statute abolishes such defenses as contributory negligence, assumption of risk, and the negligence of fellow servants, only where the employer is free to accept or reject the statute, and it violates no constitutional rights.

Hunter v. Colfax Consolidated Coal Co. (Iowa), 154 Northwestern, 1037, p. 1066, November, 1915.

DEFENSE OF CONTRIBUTORY NEGLIGENCE IN MITIGATING DAMAGES.

In an action under the Iowa workmen's compensation act by a miner for injuries alleged to have resulted from the negligence of a mine operator, the mine operator may plead and prove contributory negligence of the injured miner by way of mitigation of damages.

Hunter v. Colfax Consolidated Coal Co. (Iowa), 154 Northwestern, 1037, p. 1069, November, 1915.

DEFENSES AVAILABLE TO EMPLOYER.

The provision of the Iowa workmen's compensation act to the effect that willful negligence of an employee, with intent to cause his own injury, and negligence on his part, due to intoxication, remain defenses, deals with cases where both master and servant are, or may be, in varying degrees to blame, and limits the defense that the employer is not liable because the employee contributed to his own injury, either by willful self-infliction, or by negligence due to drunkenness; but the fact that the two specified acts of negligence on the part of the employee remain a defense does not prevent an employer from showing that whoever else was to blame or whoever contributed, or whatever the mental attitude or condition of the contributor may have been, the employer himself was in no manner to blame. Such a provision settles how far the negligence of the employee remains available as a defense, but does not touch the question whether the freedom of the employer from all blame remains a defense.

Hunter v. Colfax Consolidated Coal Co. (Iowa), 154 Northwestern, 1037, p. 1041, November, 1915.

EFFECT ON ASSUMPTION OF RISK.

MINER'S KNOWLEDGE OF DANGER—ASSUMPTION OF RISK.

Under the bituminous mining act of Pennsylvania there can be no recovery for the death of a miner who was a man of mature age and of extended experience as a miner and had knowledge and appreciation of his danger, and who knew that under the mining act he was required to quit work and vacate the place, where his working place was known to be unsafe, and where he knew of the presence of a dangerous rock in the roof that he could not himself remove, and where

without assistance he resumed work and apparently undertook to take down the dangerous rock that caused his death, as in such case the conclusion is that he assumed the risk.

Vagasiki v. Consolidated Coal Co., 225, Federal, 913, p. 922.

DANGER OBVIOUS.

There can be no recovery under the Virginia mining act of 1912 for the death of a miner who had had large experience as such where the roof of his working place was in an obviously dangerous condition and he had ordered timbers to make it safe, which had not been received, and where an ordinarily prudent man could have seen for himself the peril of remaining in the place where he was working, and where the deceased was, within an hour of the accident, repeatedly warned of the danger that confronted him and told that unless he came out he would be killed.

Huttel Coal & Coke Co. v. Lawrence (Virginia), 86 Southeastern, 151, p. 152, September, 1915.

NEGLIGENCE OF OPERATOR—CAUSAL RELATION TO INJURY.

The abolition of the doctrine of assumption of risk by the workmen's compensation act of West Virginia does not proscribe acts on the part of an employer, which by the common law were rightful and free from negligence, but its purpose is to forbid an application of the principle of waiver by which at common law the servant is made to assume the risk of known negligence on the part of the master, by reason of his continuing in the service with knowledge of such negligence; but in order to make a master or mine operator liable for an injury to a servant or to a miner, by reason of his omission of a duty imposed upon him by statute, in favor of the servant or miner, the existence of a causal relation between such omission and the injury is essential.

De Francesco v. Piney Mining Co. (West Virginia), 86 Southeastern, 777, p. 778, October, 1915.

MINER DOES NOT ASSUME RISK OF BREACH OF STATUTORY DUTY.

A miner with knowledge that a mine operator has not complied with a statute requiring certain structures to be placed in a shaft for the protection of miners can not be charged with assumption of risk to defeat a recovery for injuries caused by the failure of the operator to comply with the statute; and the rule applies though the statute fixes a penalty on the operator for its violation, where there is nothing in the act to indicate that the penalty was exclusive of the miner's right to maintain an action for damages.

American Zinc Co. v. Graham (Tennessee), 179 Southwestern, 138, p. 140, October, 1915.

ASSUMPTION OF RISK AND ABSENCE OF CONTRIBUTORY NEGLIGENCE.

The abolition of the doctrine of assumption of risk goes only to that portion of the statute which denies a right of recovery for negligence on the part of the master, to which the servant is deemed to have assented, because of his knowledge of the same and continuance in the service thereafter. It was not the purpose of the statute to proscribe acts on the part of the master which, by the common law, were rightful and free from negligence, but only to eliminate an application of the principle of waiver—assumption of risk of injury by known acts of negligence on the part of the master. An employer or mine operator who has not elected to bring himself within the provisions of the workmen's compensation act is not answerable for injuries sustained by an employee, in the absence of some negligence on the part of the employer or mine operator.

De Francesco v. Piney Mining Co. (West Virginia), 86 Southeastern, 777, p. 780, October, 1915.

DEFENSE ABOLISHED BY STATUTE.

Assumption of risk on the part of a miner is no defense to an action for the death of a miner under the second, third, and fifth clauses of section 3910 of the Alabama Code of 1907, for the reason that to permit it would be to emasculate the employers' liability act and to rehabilitate the common law doctrine of fellow servants as applicable to the cases provided for in these clauses, when the clear purpose of the act is to destroy the defense of assumption or risk, and under these clauses a miner does not assume the risk incident to the negligence of the operator or of a person to whom superintendence was entrusted.

Standard Steel Co. v. Clifton (Alabama), 69 Southern, 937, p. 938, October, 1915.

DEFENSE OF ASSUMPTION OF RISK ABOLISHED.

It is within the power of a legislature to eliminate by statute the various defenses resting on risks assumed by an employee on the ground that these rules have been evolved by the courts and may properly be abrogated by the legislature.

Hunter v. Colfax Consolidated Coal Co. (Iowa), 154 Northwestern, 1037, p. 1066, November, 1915.

ASSUMPTION OF RISK ABOLISHED—APPLICATION OF RULE.

Statutes which in terms abolish the doctrine of assumption of risk as a defense go no further than to abolish the defense where the servant is injured by reason of the employer's negligence, and do not abolish assumption of risk where the employer has not been negligent.

Hunter v. Colfax Consolidated Coal Co. (Iowa), 154 Northwestern, 1037, p. 1043, November, 1915.

EFFECT ON NEGLIGENCE OF FELLOW SERVANT.

DEFENSE OF CONTRIBUTORY NEGLIGENCE OF FELLOW SERVANT ABOLISHED.

The primary and general purpose of the Alabama statute is to abolish, in the specified cases, the rule which exempts mine operators from liability to answer in damages for an injury suffered by one miner by reason of the negligence of a fellow miner; but when a miner who is injured and a miner whose negligence caused the injury are of the same grade, and as to all employees or miners who do not come within either of the specified statutory classes, the common law rules apply. The statute gives an injured miner a right of action in the enumerated cases as if he were a stranger, rightfully and lawfully on the premises of the operator, and takes away the defense of common employment, and the purpose of the statute is to protect the miner against the special defenses growing out of, and incidental to, the relation of employer and employee; and the result is to take from a mine operator such special defenses, but to leave him all the defenses which he has by the common law against a stranger, not a trespasser, nor a bare licensee.

Standard Steel Co. *v.* Clifton (Alabama), 69 Southern, 937, p. 940, October, 1915.

STATUTORY ACTION FOR WRONGFUL DEATH.

ACTION IN UNITED STATES COURTS—CONSTRUCTION OF STATE LAW—JUDICIAL NOTICE.

Where an action is brought in a United States court to recover damages for the death of a miner under the Pennsylvania State statute, the Federal court will take judicial notice of the statutes and judicial opinions of that State and the Federal court is bound by the construction given to such act by the courts of Pennsylvania.

Vagaszki *v.* Consolidated Coal Co., 225 Federal, 913, p. 917.

ACTION BY ADMINISTRATOR—PLEADING.

An administrator suing for the wrongful death of a miner can not recover in the absence of an averment of the appointment and qualification of the plaintiff as administrator.

Byer *v.* Paint Creek Collieries Co. (West Virginia), 86 Southeastern, 476, September, 1915.

RIGHT OF WIDOW TO COMPROMISE CLAIM FOR DEATH OF HUSBAND.

A widow whose husband was killed in a mine because of the alleged negligence of the mine operator, and who waived the right to take out letters of administration and administer upon the estate of her husband and sue for the wrongful death, may after the appoint-

ment of a third person as administrator, compromise and settle the claim against the mine operator for damages because of the alleged negligence resulting in the death of her husband, and a receipt and release executed by her in payment, settlement, and compromise of such claim may be pleaded in bar of an action brought by the administrator. It is immaterial in such case that the administrator was appointed before the widow effected the compromise, and the result is not changed by the fact that she consented to the appointment of the administrator, as her superior right to control the claim by compromising it or by bringing suit on it herself, can be in no wise impaired by the qualification of the administrator, and her superiority continues until she in some manner waives it, and the waiver of her right to administer is not tantamount to a waiver to her right to sue or to settle, though this power may in fact be exercised to the detriment of her interests. The settlement made by the widow can not be impeached by the administrator on the ground that it was fraudulently procured, as the widow alone could take advantage of any alleged fraud.

Spitzer *v.* Knoxville Iron Co. (Tennessee), 180 Southwestern, 163, p. 164, November, 1915.

ACTIONS AGAINST PERSONS JOINTLY NEGLIGENT.

Under the constitution and statute of Kentucky an action to recover damages for the wrongful death of a miner may be maintained against the mine operator and a fellow miner who were both guilty of the negligence causing the death.

Carter Coal Co. *v.* Prichard (Kentucky), 179 Southwestern, 1038, p. 1041, November, 1915.

PROOF OF BENEFICIARIES AND FINANCIAL CIRCUMSTANCES.

In an action by an administrator for the wrongful death of an intestate the administrator must show that some person has suffered some pecuniary injury by the death, as the statute does not imply that damages and pecuniary losses necessarily flow from a negligent killing; and in order to meet this statute it is proper in an action against a mining corporation for the death of a minor son, to show the age, calling, and condition of the father, and also the age and condition of the mother, and to show in a general way the financial circumstances of the beneficiaries, and in specific instances the indebtedness or the reason of such.

Peklenk *v.* Isle Royale Copper Co. (Michigan), 153 Northwestern, 1068, p. 1070, September, 1915.

MINES AND MINING OPERATIONS.

NEGLIGENCE OF OPERATOR—CARE REQUIRED.

NEGLIGENCE DEFINED.

Negligence may be defined to mean the failure to exercise ordinary care, or such care as is usually exercised by ordinarily careful and prudent persons under like or similar circumstances to those involved in the particular case.

Nebo Coal Co. v Barnett (Kentucky), 180 Southwestern, 79, p. 81, December, 1915.

GROSS NEGLIGENCE DEFINED.

Gross negligence may be defined as a failure to exercise slight care.

Nebo Coal Co. v. Barnett (Kentucky), 180 Southwestern, 79, p. 81, December, 1915.

DEGREE OF CARE REQUIRED—ORDINARY CARE.

Ordinary care may be defined to mean such care as is usually exercised by ordinarily careful and prudent persons under like or similar circumstances to those involved in a particular case.

Nebo Coal Co. v. Barnett (Kentucky), 180 Southwestern, 79, p. 81, December, 1915.

PROOF—CIRCUMSTANTIAL EVIDENCE.

In an action against a mine operator for the wrongful death of a miner caused by the alleged negligence of the operator, in order to make out a case it is not necessary to establish it by witnesses, but this may be done by circumstantial evidence.

Southern Mining Co. v. Lewis (Kentucky), 179 Southwestern, 1067, p. 1070, November, 1915.

NEGLIGENCE NOT PRESUMED FROM INJURY.

Negligence will not be presumed from the fact that a miner has been injured and one who alleges negligence must prove it; but in the case of death by wrongful act, the rule applies with equal force to one who alleges contributory negligence and where there is sufficient evidence to show that a mine operator was negligent in the manner in which he stopped empty cars on a track in and about an old entry and where he negligently operated the trains of cars whereby the cars standing on the track were released and permitted to run wild down the grade, and in this way the operator failed to exercise ordinary care to provide

a miner engaged in loading a car a reasonably safe place in which to work, and the operator, knowing such conditions, or in the exercise of ordinary care should have known of such conditions, and should have provided against them, and failing to do so is liable for the death of the miner.

Southern Mining Co. v. Lewis (Kentucky), 179 Southwestern, 1067, p. 1070, November, 1915.

RIGHT TO DEFEND AGAINST CHARGE OF NEGLIGENCE.

The Iowa workmen's compensation act does not prevent a coal-mine operator, in an action against it by a miner for injuries due to the alleged negligence of the operator, from defending on the ground that the operator was in no wise at fault for the alleged injury charged to it.

Hunter v. Colfax Consolidated Coal Co. (Iowa), 154 Northwestern, 1037, p. 1069, November, 1915.

DESTRUCTION OF ARTESIAN WELL.

The owner of the underlying coal is liable for negligently destroying the pipe in an artesian well sunk through his strata of coal to the substrata by the owner of the surface.

Pennsylvania Central Brewing Co. v. Lehigh Valley Coal Co. (Pennsylvania), 95 Atlantic, 471, p. 472, July, 1915.

UNGUARDED EXCAVATION—CONSTRUCTIVE NOTICE.

A mining corporation is liable for the death of a 12-year old boy who lost his life by falling into an old excavation on the property of the corporation, and in an action for damages for the death of the boy it is not necessary to prove that the defendant corporation or its officers had actual notice or knowledge of the existence of the excavation nor is it sufficient to avoid liability for the defendant to show that none of its officers had any actual knowledge of the existence of the hole; but the proximity of the excavation to a much-traveled path and the knowledge of others in the vicinity of its existence, together with all the circumstances surrounding the situation, were sufficient to have the case submitted to the jury on the question whether the officers of the defendant corporation in the exercise of reasonable diligence ought not to have been aware of the excavation.

Peklenk v. Isle Royale Copper Co. (Michigan), 153 Northwestern, 1068, p. 1069, September, 1915.

REMOTE CAUSE OF INJURY.

Where it appeared that a mine operator was negligent in permitting a track in the mine to be laid and operated with cars dangerously near a rib without affording protection to employees, this is not sufficient to render the operator liable for the death of a miner caused by

being struck and run over by a trip of cars where it appears that the dangerous proximity of the track to the road had nothing whatever to do with producing the incident.

Clinchfield Coal Corporation v. Cruise (Virginia), 86 Southeastern, 135, p. 138, September, 1915.

PLEADING NEGLIGENCE—SUFFICIENCY OF PETITION.

In an action for damages by an injured miner whose injury was caused by a rock falling from the roof of a mine the sufficiency of the petition will not be determined by the provisions of section 8473 of the Revised Statutes of 1909 of Missouri, relating to the duty of a coal-mine operator to furnish props when requested, where the petition is not drawn under such section, as the remedy under that section is not exclusive and the common law remains open to the redress of an injured miner.

Atwell v. Marceline Coal & Mining Co. (Missouri Appeals), 180 Southwestern, 400, p. 401, November, 1915.

DEFECTIVE ROOF—FAILURE TO INSPECT AND REPAIR.

A complaint and petition for damages for injuries to a miner is sufficient after verdict where it alleges the defect in the roof and that the mine operator's boss knew of such defect and that the plaintiff requested him to build cribs for its support and thereupon such boss promised to do so but delayed for several days and until the roof fell and injured the plaintiff; and alleging also that although the plaintiff made such request, he thought he could continue to work in safety until the foreman complied with his promise to secure it, as every reasonable intendment will be indulged after verdict in favor of the petition stating a good cause of action.

Atwell v. Marceline Coal & Mining Co. (Missouri Appeals), 180 Southwestern, 400, p. 401, November, 1915.

DUTY TO FURNISH SAFE PLACE.

USE OF ORDINARY CARE TO FURNISH SAFE PLACE.

It is the duty of a coal company engaged in mining coal to exercise ordinary care to furnish a miner a reasonably safe place in which to work, and this duty carries with it the duty of inspection and the duty of supporting the roof with timbers in the event an inspection discloses the necessity for timbering; and where there was evidence tending to show that the roof where the miner was injured was unsafe and that this condition by the exercise of ordinary care could have been discovered in time to have protected the roof, if ordinary care had been exercised to adopt this method of safety after the attention of the company was called to the necessity for supporting the roof, under such circumstances the mine operator will be held liable for injuries resulting to a miner.

Carter Coal Co. v. Prichard (Kentucky), 179 Southwestern, 1038, p. 1043, November, 1915.

SAFE PLACE—EXCEPTIONS TO THE RULE.

The rule requiring a mine operator to furnish the miner a safe place in which to work does not generally apply when the miner himself is engaged in making the place and when the situation is constantly changing.

Calumet Fuel Co. v. Rossi, (Colorado), 151 Pacific, 935, p. 936, October, 1915.

EXCEPTION—MINER'S KNOWLEDGE OF CUSTOM.

In the absence of a positive rule of law imposing upon a mine operator the duty of safeguarding an entry or a traveling way through a miner's room there is no reason why a general custom, known to the miner, under which miners assume the duty of keeping safe the rooms and the ways, is not binding upon the miner; and in an action by a miner injured by a fall of rock from the roof, the mine operator is entitled to have the jury pass upon the matter of the custom and the miner's knowledge of it; and instructions by the court to the jury which prevent the mine operator from having his case thus presented are erroneous and sufficient to cause a reversal of the case.

Calumet Fuel Co. v. Rossi (Colorado), 151 Pacific, 935, p. 936, October, 1915.

MINER MAKING PLACE.

The rule that an employer must furnish an employee a reasonably safe place in which to work does not apply where the employee furnishes his own place or where the place is continually changing by reason of the work itself; and a miner as he removes the coal from his room makes a place in which he must work after the coal is removed and is continually changing the place by reason of the work being done.

Brooks v. Central Coal & Coke Co. (Oklahoma), 152 Pacific, 616, p. 617, November, 1915.
Van Hook v. Hamilton Coal & Mercantile Co. (Kansas), 152 Pacific, 640, November, 1915.

DISTINCTION BETWEEN FURNISHING AND MAINTAINING SAFE PLACE.

An action for the death of a miner caused by the negligent failure of a mine operator to provide the intestate with a reasonably safe place in which to work is not supported by evidence showing that the operator negligently failed to maintain a safe place, as the duty of maintaining a safe place in which to work is a delegable one, while the duty of providing such a place is not; and where the only negligence attempted to be shown was the failure to inspect the roof of the room in which the intestate was injured, or the failure to securely prop the same or to remove the loose rock or slate which fell upon the intestate, either of these, if considered a defect, was one which arose in the progress of the work, as there could be no roof until the ore

was removed, nor could it be inspected or propped, or the loose rock removed until the coal was mined and removed, and to maintain this kind of safety is a delegable duty and the proof shows that it was delegated, and if negligence occurred in the maintenance of such a place, it is that of the operator or its agent, and for such the statute alone makes the operator liable; and if the negligence of the mine operator was a failure to maintain a safe place for the miner, a recovery can not be had under the allegation that the mine operator was negligent in failing to provide the intestate with a reasonably safe place.

Standard Steel Co. v. Clifton (Alabama), 69 Southern, 937, p. 940, October, 1915.

INJURY TO INEXPERIENCED MINER—DUTY TO INSPECT.

A mine operator is liable to a miner for injuries caused from the fall of slate from the roof of an entry where the miner was working and where it appears that the miner could not speak English, and that he was nearsighted and not in the habit of doing any work about the mine that required skill or training, and where it was no part of his business or duty to look after the condition of the roof at the place where he was working, and where the company had other men employed to inspect the roof.

East Jellico Coal Co. v. Closterides (Kentucky), 178 Southwestern, 1152, October, 1915.

EVIDENCE AS TO DEFECTIVE CONDITION OF ROOF BEFORE AND AFTER ACCIDENT.

In an action by a miner for injuries caused by a fall of slate from the roof it is proper for miners who were not present at the time of the injury, but who were present the day and the night before and after the injury, to testify as to the condition of the roof and that they saw loose slate in the roof of the entry, or that some of the loose slate had fallen from the roof, and that they discovered after the injury that a part of such loose slate had fallen.

East Jellico Coal Co. v. Closterides (Kentucky), 178 Southwestern, 1152, p. 1153, October, 1915.

WILD CARS IN HAULAGE WAY.

A mine operator is not liable for the death of a miner caused by a trip of cars breaking out of a room, being insecurely scotched and running out and down the haulage way without lights or signals and running upon and over the miner who was using the haulage way as a walk way, where the operator had provided proper means for signaling the approach of cars to employees using the haulage way and where the usual thing was the use of the haulage way by a motor and cars, with a motorman and brakeman carrying lights and keeping the cars under control, as it is the probable and not the improbable danger which a

mine operator must foresee and guard against and he is not bound to foresee and provide against the unusual and improbable thing that occurs.

Clinchfield Coal Corporation v. Cruise (Virginia), 86 Southeastern, 135, p. 138, September, 1915.

EVIDENCE TO SUPPORT VERDICT AS AGAINST DEMURRER.

Where a mine owner and operator had mined out and completed according to his plan of work certain entries or rooms in its mine, the evidence of an injured miner to the effect that he was expressly directed to enter such abandoned part or room, without any knowledge on his part that it had been so abandoned and that there were no sufficient visible indications of its abandonment and was there injured in the course of his employment, is sufficient to sustain a verdict in his favor as against a demurrer to the evidence.

Osborn v. Darby Coal Mining Co. (Virginia), 86 Southeastern, 834, p. 835, November, 1915.

DUTY NOT DISCHARGED BY INSPECTION.

A mine owner and operator can not escape liability for an injury to a miner unless it appears that the duty of inspection was imposed upon the injured miner, or it is shown that the danger was so obvious as that a person of ordinary intelligence could, in the exercise of ordinary care, have discovered the peril; but the inspection of the roof is not conclusive evidence of the exercise of the required degree of care on the part of the coal-mine operator, and if the inspector decides that the roof is safe and supports are not necessary, this may not exonerate the mine owner or operator in the event an injury happens by the falling of the roof.

Carter Coal Co. v. Prichard (Kentucky), 179 Southwestern, 1038, p. 1043, November, 1915.

DUTY TO PROVIDE SAFE APPLIANCES.

INSTRUMENTS FOR SCOTCHING CARS.

A mine operator is not to be charged with negligence for failure to furnish the kind of instrumentalities commonly used and relied upon in a mine for scotching cars, where in the instant case it appears that if the instrumentalities were improperly and negligently used the fault lay with the fellow servant, for whose negligence the mine operator is not liable; but in any event the operator is not liable where the injured employee used the same scotch that had often been used in the same room and where he believed it would make the cars safe and secure at the time and where there were other props near by in abundance that he could have used if he believed the one used unsuited.

Clinchfield Coal Corporation v. Cruise (Virginia), 86 Southeastern, 135, p. 137, September, 1915.

INSUFFICIENT APPLIANCE—REMOTE CAUSE OF INJURY.

In an action by a miner for damages caused by the derailment of a motor due to a defect in the track it is error for a court to instruct the jury to the effect that the plaintiff is entitled to recover if the crab rope or cable was not of sufficient length to reach from the motor on the entry track to a loaded car in the miner's room, though the evidence tended to show the insufficient length of such crab rope and that this did make it necessary for the motor to come on to the room track, but where in fact the crab rope was not being used and no attempt had been made to use it at the time of the accident.

Consolidated Coal Co. *v.* Moore (Kentucky), 178 Southwestern, 1136, p. 1137, October, 1915.

DEFECTIVE CONDITION OF MACHINERY—QUESTION OF FACT.

In an action by a miner for injuries caused while cutting coal, and due to the alleged defective condition of the machine used, in that when the air was turned on it caused the machine to start with a jerk and such resulting jerk caused the injuries complained of, and where it was claimed that if the machine had been in good order it would have worked smoothly when the air was turned on, and the accident would not have occurred, the question, under such circumstances, as to whether or not the defective condition of the machine was the proximate cause of the injury is one of fact to be determined by the jury.

Stearns Coal & Lumber Co. *v.* Calhoun (Kentucky), 179 Southwestern, 500, November, 1915.

MINER'S KNOWLEDGE OF DEFECTIVE APPLIANCE—ASSURANCE OF SAFETY.

A miner in an action for personal injuries is entitled to have his case submitted to the jury where his injury was caused by the breaking of a jack pipe furnished him by the machine boss, where the miner knew the pipe was rusty and where he had objected to the use of the pipe, but was assured by the mine boss that it was good for two or three months, and that he, the boss, knew better than the miner, and where the superintendent assured the miner that the machine boss would see that a new pipe was furnished and directed him to go on with the work until a new pipe was furnished, though the testimony of the injured servant was contradicted by both the machine boss and the superintendent.

Keystone Coal & Coke Co. *v.* Petrovich, 227 Federal, 43, p. 45.

DUTY TO WARN OR INSTRUCT.

NEGLIGENCE OF FELLOW SERVANT—FAILURE TO WARN.

The duty to warn where timbermen are engaged in setting timbers and propping the roof of a mine in order to make a safe place is a

delegable duty and is fully performed when the mine owner or operator selects a suitable and competent fellow servant experienced in the work, and makes it his duty to give the warning; and such competent fellow workman does not stand in the relation of foreman or shift boss to the mine operator, but is simply a fellow miner of the timbermen, assisting him, and does not by reason of his seniority in the work at the place represent the owner or operator so as to make it liable for his negligence.

Aho v. Cleveland-Cliffs Iron Co. (Michigan), 154 Northwestern, 82, p. 55, September, 1915.

VICE PRINCIPAL—WARNING MINER OF DANGER—LIABILITY OF MASTER.

Where it was the duty of a mine operator to cross timber the rooms of a mine and the operator selected a person to perform the work and to do the work when the conditions required, it must be presumed that such person possessed superior knowledge of the danger, or lack of danger, growing out of the roof; and as the duty of cross timbering devolved upon the operator, and as the duty was intrusted to a person selected, he became a vice principal and took the place of the operator, and his assurance of safety to a miner was in effect an assurance by the master; but the rule operates both ways, and if the miner had the right to rely on the assurance of safety made by the vice principal, he should be required, on the other hand, to heed the warning of danger where such vice principal warned the miner of the dangerous condition of the roof and of the danger of working thereunder a sufficient length of time before the accident to enable the miner, by the exercise of ordinary care, to stop work and avoid the peril, and the operator can not be held liable where the miner continued in his working place as against such warning, and was injured.

Carter Coal Co. v. Hill (Kentucky), 179 Southwestern, 2, p. 4, October, 1915.

ABANDONED ROOMS—FAILURE TO WARN MINER.

A mine owner and operator has the right to abandon places in his mine which have been completed according to the plan of the work, and if a room in which a miner was directed to work had been abandoned, there being no sufficient visible indications of its abandonment, the mine owner would be liable for negligence to a miner entering such abandoned part or room and being injured in the course of his employment, if the mine operator failed to give due and timely warning of such abandoned part or room.

Osborn v. Darby Coal Mining Co. (Virginia), 86 Southeastern, 834, p. 835, November, 1915.

WARNING UNNECESSARY AS TO ORDINARY DANGERS.

The failure of a mine operator to warn an inexperienced coal miner of the danger incident to the taking from a drill hole of a stick of dynamite with an ignited fuse attached, almost immediately after discovery of lack of scintillation by the fuse, is not negligence, as any person of ordinary intelligence presumptively knows that a fuse will sometimes burn without scintillating; and the mine operator is not liable for an injury resulting from such an act. Under such circumstances there was nothing in the situation of the miner that might reasonably have induced the operator or his agents to anticipate the act of the miner where there was nothing to show that he lacked the intelligence ordinarily characteristic of a mature man and knew that dynamite would explode, and no one could have thought it necessary to advise him against taking up a stick of dynamite to which a lighted fuse was attached.

De Francesco *v.* Piney Mining Co. (West Virginia), 86 Southeastern, 777, p. 780, October, 1915.

LIABILITY FOR NEGLIGENCE OF FELLOW SERVANT.

WHO ARE FELLOW SERVANTS.

The rule is that all who serve the same master, work under the same control, derive authority and compensation from the same common source, and are engaged in the same general business, though it may be in different crews or departments of it, are fellow servants; but the employees need not be engaged in the same common work at the same time and the "con-association doctrine" does not apply, but it is sufficient if the servants are in the employment of the same master, engaged in the same common work and performing duties and services for the same general purpose. Under this rule a miner employed on a night shift engaged in the work of removing old timbers from a sublevel in a mine and replacing them with new ones is a fellow servant with a miner working on a day shift performing the same work.

Kangas *v.* Cleveland-Cliffs Iron Co. (Michigan), 154 Northwestern, 41 p. 42, September, 1915.
Aho *v.* Cleveland-Cliffs Iron Co. (Michigan), 154 Northwestern, 52 p. 54, September, 1915.

FELLOW SERVANT OF EQUAL GRADE.

A mine operator is not liable to a miner for injuries incurred by him on account of the negligence, either ordinary or gross, of a fellow servant in the same work and occupying the same situation as to authority as himself.

Nebo Coal Co. *v.* Barnett (Kentucky), 180 Southwestern, 79, p. 81, December, 1915.

LIABILITY FOR GROSS NEGLIGENCE OF SUPERIOR FELLOW SERVANT.

Where in making up trips or trains of cars it was the duty of a brakeman in a coal mine to couple or uncouple the coal cars and give to the

motorman proper signals to "go ahead" or "back up" and when the trip was ready the brakeman would get aboard, either on the car or on the motor, as the situation required, and the motorman would then take the trip to its destination; and while in making up the trip the motorman responded to the brakeman's signals, yet at all other times the motorman had sole charge and control of the train and in that regard was superior in authority to the brakeman; and while the two employees were in the manner described associated together in the same work, yet they were not in the same grade of employment, their relative duties were not unlike that of the ordinary railroad engineer and brakeman; but an engineer and brakeman are not fellow servants although employed on the same train; and in an action by the brakeman for damages caused by the alleged gross negligence of the motorman, the court properly instructed the jury that the brakeman was entitled to recover if his injuries resulted from the gross negligence of the motorman.

Consolidated Coal Co. v. Baldridge (Kentucky), 179 Southwestern, 18, October, 1915.

NEGLIGENCE OF SUPERIOR SERVANT NOT IMPUTED TO OPERATOR.

The ordinary negligence of a superior servant which results in an injury to a miner, which does not produce death, can not be imputed to the mine operator.

Nebo Coal Co. v. Barnett (Kentucky), 180 Southwestern, 79, p. 81, December, 1915.

RECKLESS OPERATION OF MOTOR.

In the operation of a motor and cars in a coal mine proof of a jerk that is violent, unusual, and unnecessary is evidence from which negligence on the part of the person operating the motor may be inferred.

Nebo Coal Co. v. Barnett (Kentucky), 180 Southwestern, 79, p. 80, December, 1915.

MINERS' WORKING PLACE—SAFE PLACE.

SAFE PLACE DOCTRINE—APPLICATION TO MINER'S WORKING PLACE.

The rule that an employer or a mine operator is required to furnish his employee or miner a safe place in which to work, and to see that the environment in which the employee or miner performs his duty is kept in a reasonably safe condition, is not applicable where such environment becomes unsafe solely through the fault of the employee or miner himself, or of his fellow employees, and the obligation of the employer or operator to protect his employees does not extend to protecting them from the transitory risks which are created by the negligence of the employees themselves in carrying out the details of the work.

Standard Steel Co. v. Clifton (Alabama), 69 Southern, 937, p. 940, October, 1915.

DUTY TO EXERCISE CARE—QUESTION OF FACT.

It is the duty of a miner working in a coal mine to exercise ordinary care for his own safety although he is not charged with the duty of inspecting, and if the unsafe condition of the roof at the place where he is working is so obvious that a person of ordinary intelligence, in the exercise of ordinary care for his own safety, could not have failed to discover it, this would amount to such contributory negligence as to defeat a recovery; but this was a question of fact to be submitted to and determined by a jury.

Carter Coal Co. v. Prichard (Kentucky), 179 Southwestern, 1038, p. 1042, November, 1915.

EXCEPTIONS TO RULE—MINER MAKING PLACE SAFE.

The rule as to the duty of a mine operator to furnish safe places for his miners and employees in which to work applies to a timberman whose duty it is to timber a stope or the roof of a room for the purpose of making the place safe; and the fact that a timber boss was employed to care for the safety of his crew does not make him a vice principal performing the nondelegable duty to furnish the timberman a safe place, and the duties of such timber boss in caring for the safety of his crew are not in their nature different in principle than those of timber bosses generally.

Kangas v. Cleveland-Cliffs Iron Co. (Michigan), 154 Northwestern, 41, p. 42, September, 1915.
Aho v. Cleveland-Cliffs Iron Co. (Michigan), 154 Northwestern, 52, p. 54, September, 1915.

EXERCISE OF CARE TO AVOID INJURY.

It is the duty of a miner to exercise care to avoid injuries, and he is under as great obligation to provide for his own safety from such dangers as are known to him, or are discernible by ordinary care on his part, as the master is to provide for him; and he must take ordinary care to learn the dangers which are likely to beset him in the service and must not go blindly to his work where there is danger. This rule applies both under the common law and under the statutory provisions prescribing the relative duties of the miner and operator.

Virginia Iron, Coal & Coke Co. v. Asbury (Virginia), 86 Southeastern, 148, p. 149, September, 1915.

VIOLATION OF RULES.

The violation by a miner of a rule of the mine operator, promulgated for the protection of the miner, will defeat a recovery by the miner for an injury when the observance of the rule would have prevented the injury complained of, as obedience to the rules of an employer can not be more obligatory upon an employee than his obedience to a statute enacted for his benefit, and it is the rule that a violation of the latter is negligence per se.

Virginia Iron, Coal & Coke Co. v. Asbury (Virginia), 86 Southeastern, 148, p. 151, September, 1915.

FAILURE TO INSPECT ROOF AFTER SHOTS—DUTY OF MINER.

It is the duty of a miner working in a coal mine where shot firers are provided to inspect his room and the place at which he is working after a shot has been fired, for the purpose of discovering anything that might be dangerous; and where a miner left his room with its props in proper and safe condition and found them down on his return after shots had been fired, he should then have inspected the roof of his room to ascertain its condition, and if defective he must act accordingly. It was not the duty nor was it necessary for the mine operator to inspect the miner's room after the shot was fired before the miner returned to his work in the room; and under such circumstances it is not actionable negligence on the part of the operator to fail to inspect the miner's room after the shot had been fired.

Brooks v. Central Coal & Coke Co. (Oklahoma), 152 Pacific, 616, p. 617, November, 1915.

MINER'S SCOPE OF EMPLOYMENT—INJURY AND LIABILITY.

SCOPE OF EMPLOYMENT—INJURY OUTSIDE OF EMPLOYMENT.

There can be no recovery for the death of an employee in a mine where his regular employment was in the capacity of assistant boss driver and where he gratuitously, or without proper authorization, undertook to aid in the work of repairing a trip wreck in the mine, and in so doing came in contact with an electric wire, thereby causing his death.

Republic Iron & Steel Co. v. Quinton (Alabama), 69 Southern, 604, p. 605, July, 1915.

DRIVER ASSISTING IN REMOVING WRECK.

A mine owner and operator is liable for the death of an employee whose regular employment was in the capacity of assistant boss driver, where the bank boss called upon the boss driver and his assistant to assist in removing a trip wreck and while so engaged the assistant boss driver, without any negligence on his part, came in contact with a live electric wire and was killed.

Republic Iron & Steel Co. v. Quinton (Alabama), 69 Southern, 604, p. 606, July, 1915.

MINER WAITING FOR WORK—SCOPE OF EMPLOYMENT.

Where a miner reports to the place or room for work as directed, and upon arrival he found that the room was not quite ready, in that the track, being laid by another employee, was not in proper position and that it was necessary to pull the track over to the side of the room, and the employee being unable to do this alone requested the miner to assist him, and after assisting in removing the track and while assisting the employee in setting some timbers, the miner

was injured from an explosion in an adjoining room and which broke through the connecting wall, causing the injury complained of, a recovery of damages is not to be denied him on the ground that he was not in the course of his employment and that he was a mere volunteer, or assisting the employee to discharge duties which such employee alone was under obligation to perform, as he was at the place where he had been ordered to report for work, and whether he sat down to watch the other employee make the place ready, or whether he voluntarily assisted such employee in doing so, the operator's duty to provide him a reasonably safe place obtained.

Moses. Proctor Coal Co. (Kentucky), 179 Southwestern, 1043, p. 1044, November, 1915.

MINER ENTERING DANGEROUS ROOM AFTER WORKING HOURS.

A miner who entered a room in a mine for the purpose of inspecting either upon the orders of the bank boss or with his knowledge and consent and where such bank boss knew of the existence of gas in the room, or negligently failed to ascertain the fact before ordering or permitting the miner to enter such room, is not to be denied the right to recover for injuries caused by the presence of the gas because he entered the room and the injury was sustained after he had finished his daily task, but where it also appears that he was due to remain in the mine beyond the time at which he received the injury; and if for some good reason he went to another part of the mine upon the order or with the consent of his superior he was still an employee entitled to the protection of the law governing such a relationship and answerable to the duties imposed upon him.

Woodward Iron Co. v. Lowther (Alabama), 69 Southern, 877, p. 879, October, 1915.

MINER WALKING BESIDE MOTOR.

A miner after a long delay on the part of the motor man in coming for his loaded car went to the entry and requested the motor man to get the car and returned walking by the side of the motor and while so doing the motor was derailed by reason of a defect in the track, and the miner's foot was caught between one of the rails and a gob of slate lying nearby and crushed and broken. Under such circumstances recovery can not be denied, on the ground that the miner was at a place where the duty of the master to use ordinary care to furnish him a safe place in which to work, or reasonably safe appliances for work, did not apply, as under the circumstances the miner was acting in the course of his employment.

Consolidated Coal Co. v. Moore (Kentucky), 178 Southwestern, 1136, October, 1915.

QUESTION OF FACT—SCOPE OF EMPLOYMENT.

Where a miner was working outside the mine and had just finished loading eight mine cars with timber and while the motor was hauling

them into the mine and he was walking behind the cars along the track toward his place of regular work, a wild empty mine car came down the grade from the rear and ran over him, in an action by his administrator for wrongful death, the question whether such death was due to the employing company's negligence was a question of fact for the jury.

Southern Mining Co. *v.* Lewis (Kentucky), 179 Southwestern, 1067, p. 1068, November, 1915.

CONTRIBUTORY NEGLIGENCE OF MINER.

VOLUNTARY SERVICE OUTSIDE OF EMPLOYMENT.

To entitle a miner to recover for injuries, the injuries must be received while rendering the service required by the particular employment or in obeying the orders of his superior to which the employee is bound to conform; but injuries received while doing other more hazardous service not pertaining to the employment, by way of accommodation or which are self-assumed, are not sufficient to justify a recovery against the mine operator.

Republic Iron & Steel Co. *v.* Quinton (Alabama), 69 Southern, 604, p. 606, July, 1915.

MINER GOING IN FRONT OF CAR.

A miner directed by a mine foreman to take an empty car from the drift mouth down a new entry to the face of the coal was directed to call another miner to assist him, and the two proceeded to let the car down the entries by walking behind it holding it with their hands; and when they arrived at a point about eight feet from the face of the coal the foreman called the assistant to return to the drift mouth, and as the assistant was leaving the miner inserted sprags in the wheels on the right-hand side of the car and brought it to a stop some three feet from the face of the coal and thereupon put a block or scotch under the front wheel, but fearing the car would roll over this on account of the grade, he went in front of the car for the purpose of blocking the wheel on the other side, and while in front, the car from some cause started, caught him against the face of the coal, and caused the injuries of which he complains. Under such circumstances the miner can not recover for the injury, as he undertook to exercise his own judgment as to the safety of going in front of the car instead of behind it and the withdrawal of the assistant at the direction of the mine foreman in no way contributed to the injury, and the injuries complained of were the direct result of his own want of care.

Riddle *v.* Wisconsin Steel Co. (Kentucky), 178 Southwestern, 1064, September, 1915.

FREEDOM FROM CONTRIBUTORY NEGLIGENCE.

EXERCISE OF DUE CARE PRESUMED—PRESUMPTION.

In an action against a mining corporation for the death of a boy caused by falling into an unguarded excavation, in the absence of

any proof as to the contributory negligence of the boy, it will be presumed that he was in the exercise of due care and the question of his contributory negligence or freedom from contributory negligence under the circumstances is a question of fact for the jury.

Peklenk v. Isle Royale Copper Co. (Michigan), 153 Northwestern, 1068, p. 1070, September, 1915.

BURDEN OF PROOF.

In an action for the death of a miner alleged to be caused by the negligence or wrongful act of the mine operator, the burden is upon the operator to show the contributory negligence of the deceased miner upon which it relies for a defense.

Southern Mining Co. v. Lewis (Kentucky), 179 Southwestern, 1067, p. 1069, November, 1915.

RISKS ASSUMED.

ASSUMPTION OF RISK AS A QUESTION OF LAW.

Ordinarily the question of whether a miner has assumed the risk of dangers incident to his employment is a question of fact for a jury to determine, but where the alleged causes of the dangers by which the miner was injured are so open and obvious, and the knowledge on the part of the miner so complete as to leave no doubt that he knew or ought to have known all about them, the question of the assumption of the risk becomes one of law and will bar a recovery for injuries under such circumstances.

Clinchfield Coal Corporation v. Cruise (Virginia), 86 Southeastern, 135, p. 138, September, 1915.

EMPLOYEE PERFORMING OUTSIDE SERVICES AT REQUEST OF FELLOW EMPLOYEE.

Where a miner employed in a mine is injured while acting outside of the scope of his regular employment, at the command or request of another employee, the employer is not liable, unless the latter employee is, either expressly or impliedly, authorized to make the command or request.

Republic Iron & Steel Co. v. Quinton (Alabama), 69 Southern, 604, p. 606, July, 1915.

RULES AS TO SCOTCHING MINE CARS.

There is no duty resting upon a mine operator to promulgate rules in so small a matter as the scotching of mine cars, but the lack of such rules and the uniform practice and method of doing the work in the mine are matters necessarily within the actual knowledge of an employee engaged in doing such work, and it must be assumed under such circumstances, where a miner made no protest whatever, that he assumed the risk of any dangers incident to such lack of rules and to such method of work.

Clinchfield Coal Corporation v. Cruise (Virginia), 86 Southeastern, 135, p. 137, September, 1915.

TIMBERMAN WORKING IN DANGEROUS PLACE.

An employee in a mine working as a timberman helping to make places safe for mining operations can not recover for injuries occasioned by a fall of rock, where the timber gang consisted of four men and the timber boss, and with them he was at work in the stope replacing timbers which had been knocked out in the night by blasting, and where, after an examination by the timber boss, the timberman with others commenced to shovel away dirt and broken rock from the footwall where timbers were to be set, and where after blasting a "block hole" the injured timberman, with the others, returned to the stope and began shoveling dirt and rock without instructions from the timber boss and before he had made an examination of the stope, and had not instructed the men to resume work nor given any assurance that the place was safe, but had given no warning of danger.

Vrelenich v. Calumet & Hecla Mining Co. (Michigan), 154 Northwestern, 39, September, 1915.

KNOWLEDGE OF LACK OF BRAKES ON CARS.

Where the lack of brakes on cars operated in a mine was a general and permanent condition prevailing throughout the mine and a well-known incident to the method in which the work was being done, a miner employed and working in the mine assumes the risk of danger incident to the absence of brakes on the cars, though the presence of brakes would have added an element of safety.

Clinchfield Coal Corporation v. Cruise (Virginia), 86 Southeastern, 135, p. 137, September, 1915.

KNOWLEDGE OF DANGER—RIB CLOSE TO TRACK.

Where a dangerous condition in a mine was caused by the proximity of a rib to the track in a haulageway on one side with a dangerous electric wire on the other side, and such dangerous condition resulted from the negligence of the mine owner and was prominent and perfectly open and obvious to an experienced miner who was injured and was actually known to the miner before the injury, and where with knowledge of such dangerous condition the injured miner had been using the haulageway as a walkway for several days previous to and on the day of the injury, he must be held under such circumstances to have assumed the risk of the danger arising from the known conditions.

Clinchfield Coal Corporation v. Cruise (Virginia), 86 Southeastern, 135, p. 137, September, 1915.

KNOWLEDGE OF DANGEROUS CONDITION OF ROOF.

An experienced miner engaged in robbing pillars left standing as a support to the roof of a mine, who had observed a piece of slate hanging from the roof and had tested the same with his pick and

found it "drummy," but who with his buddy thought the slate would stand until they could finish their work at that place, is not entitled to recover for an injury received from the falling slate, though he had properly requested props but the operator had failed to furnish them, where there was no assurance from the mine boss or other person representing the company that the place was safe.

Imperial Jellico Coal Co. v. Fox (Kentucky), 179 Southwestern, 1032, p. 1033, November, 1915.

DANGER OBVIOUS.

Where the danger from loose slate in the roof is so obvious to an experienced miner that no man of ordinary prudence would continue to work under such circumstances, a miner assumes the risk if he undertakes the work, and the operator is not liable if injury results; and this rule applies to an experienced miner who is engaged in robbing pillars in a mine and has knowledge of the dangerous condition of the roof and who knows that the cutting out of the pillars increases the danger, though the miner properly requested props which had not been furnished.

Imperial Jellico Coal Co. v. Fox (Kentucky), 179 Southwestern, 1032, p. 1033, November, 1915.

NEGLIGENCE OF FELLOW SERVANT.

A miner or other employee, when he undertakes employment, so far as the mine operator is affected, assumes all the risks from injuries to himself which are caused by the negligence, either ordinary or gross, of his fellow servants who are upon the same plane of equality as himself as to authority and engaged in the same work; and he likewise assumes all risks of injuries which may arise from the ordinary negligence of a superior employee in the same work as himself where the negligence does not result in death.

Nebo Coal Co. v. Barnett (Kentucky), 180 Southwestern, 79, p. 81, December, 1915.

RISKS NOT ASSUMED.

INCOMPETENCY OF FELLOW SERVANT.

An injured employee who was engaged in repairing the tracks in a mine under directions to do the work with the least possible obstruction to the cars passing in and out is not, as a matter of law, to be charged with assumption of risk of the incompetency of a motorman operating a motor and hauling cars over the track, where in the particular instance the motorman was signaled by another employee to stop before reaching the point where the repairs were being made and where the injured employee requested the other employee to signal the motorman to come ahead slowly and steadily, but instead of giving such signal the employee gave the signal to come ahead

and thereupon the motorman ran the motor and his trip of cars upon and over the place where the track was being repaired, causing a wreck and injuring the plaintiff; but the question of the assumption of the risk as well as the contributory negligence of the injured employee is one of fact to be determined by the jury.

Virginia Iron, Coal & Coke Co. v. Stanberry (Virginia), 86 Southeastern, 130, p. 131, September, 1915.

KNOWLEDGE OF INCOMPETENCY OF EMPLOYEE—LIABILITY—QUESTION OF FACT.

Where an employer knowingly employs an incompetent servant or keeps him in the employment after notice and knowledge of such incompetency, the doctrine of assumption of risk will not be applied as a matter of law to a fellow employee who also knew of such incompetency of the other employee, but the question of the assumption of risk or of the contributory negligence of the injured servant is a question of fact to be submitted to a jury for determination, rather than one of law to be determined by a court.

Virginia Iron, Coal & Coke Co. v. Stanberry (Virginia), 86 Southeastern, 130, p. 131, September, 1915.

DEFECTIVE CONDITION OF TRACK.

In an action by a miner for injuries due to the derailment of a motor caused by the defective condition of the track, it can not be said that the miner assumed the risk of the accident, as a miner does not assume the risk growing out of the operator's failure to use ordinary care to furnish him a reasonably safe place in which to work, or reasonably safe appliances, and it is only where the defect and the danger therefrom are known by the miner, or are so obvious that an ordinarily prudent person, under the circumstances, would have observed and appreciated them, that the miner can be said to have assumed the risk thereof; and in the absence of evidence tending to show that the miner knew of the defective condition of the track, or that the defect and danger were plainly observable, it must follow that he did not assume the risk.

Consolidated Coal Co. v. Moore (Kentucky), 173 Southwestern, 1136, p. 1137, October, 1915.

NEGLIGENCE OF OPERATOR.

A miner working in a mine does not assume an extraordinary risk caused by the operator's negligence.

Standard Steel Co. v. Clifton (Alabama), 69 Southern, 937, p. 938, October, 1915.

KNOWLEDGE OF DANGER.

A miner operating a punching machine for cutting coal is not to be charged with the assumption of the risk and his action for damages for injuries is not to be defeated on that ground because he knew

that the machine had stopped two or three times and its defective condition was known to him and with such knowledge he continued to work with the machine, as it is not sufficient to show merely that the miner knew of the defective condition or that it was clearly observable, but it must be made to appear that the danger from such condition was known or clearly observable and appreciated by him. The fact that he knew that the machine had stopped on two or three occasions on the morning of the injury is immaterial where it does not appear that when the machine was started it began to move with such violence that the danger therefrom was clearly observable and the miner was justified in continuing the use of the machine where the electrician, who repaired it, assured the miner that it was all right, and he had the right to rely on the assurance thus given and to continue to use the machine unless the danger was so obvious that an ordinarily prudent person would have refused to continue working with it.

Stearns & Lumber Co. v. Calhoun (Kentucky), 179 Southwestern, 590, p. 591, November, 1915.

GROSS NEGLIGENCE OF SUPERIOR SERVANT.

Under the Kentucky rule injuries which are caused to a miner or an inferior employee by the gross negligence of his superior employee are imputed to the employer or mine operator, and such an employee does not assume the risks of danger which arise from such gross negligence in an employee superior in authority to himself; but this rule is limited to cases where such superior employee has the immediate control of and supervision of the injured employee, and does not extend to cases where the superior employee's ordinary negligence causes injury to an inferior employee who is not immediately under his control and supervision.

Nebo Coal Co. v. Barnett (Kentucky), 180 Southwestern, 79, p. 81, December, 1915.

VIOLENT AND UNUSUAL JERKS OF MOTOR.

An injury received by an employee from an ordinary and necessary jerk in the operation of a motor and coal cars in a mine is the result of a risk assumed by the employee, but an injury from a violent and unusual and unnecessary jerk does not arise from such assumed risk, and proof of a jerk by a motor operating upon the coal cars which is violent, unusual, and unnecessary may be evidence of negligence on the part of the person operating the motor; and where a jolt received by a coal car, thereby causing the injury complained of, was unusual, violent, and unnecessary, a miner suing for an injury resulting therefrom is entitled to have his contention upon this subject submitted to and determined by a jury.

Nebo Coal Co. v. Barnett (Kentucky), 180 Southwestern, 79, p. 80, December, 1915.

DUTY AND LIABILITY TO TRESPASSER, LICENSEE, OR INVITEE.

VOLUNTARY WORK OUTSIDE OF SCOPE OF EMPLOYMENT.

Where an employee in a mine quits the work assigned to him by his employer and voluntarily undertakes to do work about which he has no duties to perform by virtue of the contractual relation existing between him and his employer, there is during such time and while such condition exists no duty on the part of the employer to use care for his safety.

Republic Iron & Steel Co. *v.* Quinton (Alabama), 69 Southern, 604, p. 606, July, 1915.

LIABILITY FOR OFFICER REMOVING TRESPASSER.

A coal-mine operator is not liable to a third person for an alleged assault on him by one of its officers in evicting and ejecting him from the premises of the company, where such officer used such force only as was reasonably necessary to evict the intruder, as it is the undoubted right of a lawful owner or of an occupant of premises to retain possession and to use such force as may be reasonably necessary to remove therefrom trespassers or intruders who conduct themselves in an improper manner and refuse to desist or leave on request.

Lunsford *v.* Hatfield Coal Co. (Kentucky), 178 Southwestern, 1166, p. 1167, October, 1915.

CARE TOWARD LICENSEE.

A miner who has been employed by and is working for a mine operator but who for sufficient reason was not working on the particular day but for his own purposes or in aiding a friend entered upon the premises of the mine operator is only a licensee, and the duty of the operator to him was simply not to wantonly or intentionally injure him, and the operator can not be held liable for the death of such miner who, while occupying the position of the licensee and while spending his time at the sand house, was killed by an explosion of powder in course of conveyance to the mines on one of the coal cars.

Westborne Coal Co. *v.* Willoughby (Tennessee), 180 Southwestern, 322, p. 323, November, 1915.

ACTIVE NEGLIGENCE—MEASURE OF LIABILITY TO LICENSEE.

The term "active negligence" is one of extensive meaning, obviously embracing many occurrences that would fall short of willful wrongdoing or of crass negligence and negligence of inadvertent acts causing injury to others resulting from the failure to exercise ordinary care as well as of acts the effects of which are misjudged or unforeseen, through want of proper attention or reflection, and it may cover acts of willful wrongdoing as well as those not of that character and is not a reliable term as a measure of right or duty for the purpose of determining liability for the death or injury of a licensee.

Westborne Coal Co. *v.* Willoughby (Tennessee), 180 Southwestern, 322, p. 325, November, 1915.

DUTY OF MINE OWNER TO INVITEE.

The duty of a mine owner to take proper precautions to provide a safe place for an invitee is coextensive with the premises to be used and is not limited to the immediate locality where the contemplated work is to be done, but extends to every part of the premises or mine and every instrumentality which may be visited or used by the workman for a purpose incidental and reasonably adapted to, or associated with, the accomplishment of the purpose for which the invitation was given; and a custom of a miner or an invitee to occupy a particular place in the mine may, if long continued and acquiesced in by the mine owner, amount to an implied invitation to do the act or be at the place in question, and this renders the mine owner liable for an injury to such invitee while at such place.

Patterson v. Alabama Fuel & Iron Co. (Alabama), 69 Southern, 952, p. 953, November, 1915.

INDEPENDENT CONTRACTOR.

LIABILITY OF MINE OWNER TO EMPLOYEE OF INDEPENDENT CONTRACTOR.

When a mine owner invites a second person to assist in driving an entry and in mining coal therein, and the latter is injured by reason of a dangerous condition existing at any place in the mine, the mine owner is liable if circumstances were such as to justify the inference that such second person had a legal right, derived from the mine owner, to occupy the place where his injury occurred, and if it was apparent to the mine owner, considered as a man of ordinary powers of observation, that the position likely to be assumed by such second person in the exercise of the right so acquired with respect to the owner himself or some physical agency which was under his control at the time, is such that such second person will be likely to suffer injury if the mine owner does not take precautions to prevent that injury which would occur to a prudent man as being appropriate.

Patterson v. Alabama Fuel & Iron Co. (Alabama), 69 Southern, 952, p. 953, November, 1915.

SERVANT'S USE OF DANGEROUS PLACE—LIABILITY OF MINE OWNER.

A mine owner can not be held liable for the death of a miner employed by an independent contractor, where the death was caused in an air course which was but a rough passageway for the circulation of outer air and was otherwise used only as a conduit for the power cable and was neither adapted nor designed for any other use, and this must have been clearly apparent to any man of even the least experience and intelligence, and its very use and condition was a sufficient warning to him not to enter, and the mine owner was under no duty to keep him out by guard rails or posted warning;

and his employment by a contractor to mine coal in a heading could not by any reasonable association of ideas suggest to the mine owner the likelihood of the intestate's entrance into the air course for any legitimate purpose incidental to his employment and where his presence at the place where he met his death was neither for convenience or by necessity, so far as work was concerned, and where the possible explanation was that he had stored his powder in the air course, in violation of law, and knowing that a mine inspector was inspecting the mine, he hurried into the air course to further conceal or remove the powder to prevent its discovery, and where there was nothing disclosed in the evidence to show that the mine owner knew that the air course was being used for such a purpose and did not by acquiescence impliedly invite him.

Patterson v. Alabama Fuel & Iron Co. (Alabama), 69 Southern, 952, p. 953, November, 1915.

CONTRACTS RELATING TO OPERATIONS.

MINING OUT PILLARS.

A coal lease demised all the coal and veins of coal upon the property and was to continue during such period and term as should be required to mine and carry away all the merchantable and marketable coal in, under, and upon the leased premises,, and bound the lessee to mine, take away, and pay for all the merchantable and marketable coal in and under the leased premises, and provided that the lessee should not be liable to the lessor for any injury to or falling in of the surface of the land in consequence of mining or removing the coal or of making tunnels or other openings into the same, unless damage should result from the willful misbehavior or gross negligence of the lessee. Under the terms of such a lease the owners in fee of the land which is the subject of the lease can not restrain the lessee from mining out and removing the pillars left during the course of mining operations to support the roof, and where such pillars are no longer needed to protect mining operations, as the intention of the lessors in entering into the lease was for the purpose of having the entire body of their coal mined and removed so they could realize upon it, and this was to be done without regard to the effect of the mining operations upon the surface, and the covenant against liability for injury to any part of the surface arising from the act of mining and removing all of the coal is conclusive against the lessors on the proposition that the lessee is not required under the lease to leave pillars or any part of the coal for the support of the surface, and this rule obtains although the lease provided that mining operations should be continued in a workmanlike manner and pillars should be left of such size and number as should be necessary to support the roof; and the mining and removing of the coal in such vein

should be so conducted as not to injure or interfere with the mining or removing of coal from any other vein either overhanging or underlying, so that at the expiration of the term of the lease the mines and improvements shall be left in as good order and condition for future mining as any prudent operator would leave the same were he entitled to continue mining for a series of years; but this stipulation referred only to such termination of the lease as might for some sufficient reason take place before all the coal upon the premises was mined, and it was the proper preservation of the colliery as a going concern during the course of mining that was intended to be safeguarded by this clause, so that ultimately the greatest quantity of coal could be won. And it is further observed that the pillars were to be left in the mine to support the roof and not the surface, as the support of the roof would be required in order to protect mining operations, and after the coal is exhausted such protection would no longer be necessary.

Miles v. New York & Susquehanna Western Coal Co. (Pennsylvania), 95 Atlantic, 397, p. 398, July, 1915.

CONTRACT TO PUMP WATER OUT OF MINE—DAMAGES FOR BREACH.

A judgment is sufficiently supported by the evidence where it appears that the plaintiff in an action was employed by the owner of a coal mine to pump the water out and keep it out of a certain entry in the mine, and for which he was to receive 9 cents a ton on the coal mined from the particular entry, and where the plaintiff claimed that the contract included the coal left in the pillars and stumps of the entry, and where it appeared that he could have made a clear profit of 6 cents a ton, and the verdict and judgment were based on the finding that there was 15,000 tons of coal he was entitled to have mined under his contract, but was prevented by the mine owner.

Trosper *v.* Rader (Kentucky), 179 Southwestern, 1023, November, 1915.

MINING PARTNERSHIPS.

PARTNERSHIP AGREEMENT—GRUBSTAKE CONTRACT.

An agreement stipulated that one of the parties should be a full-fledged partner with the three other persons named, and have one-quarter undivided interest in all claims, lodes, and water rights acquired and owned by the parties, the agreement stating that the one person so made a partner was to furnish the above-mentioned parties with provisions from time to time up to a stated date. The consideration for the transaction was $30,000 and the agreement provided for the payment of $6,000 cash, the balance of $24,000 to be paid "of the first money taken out of the ground." In a controversy over the mining operations and in an action to dissolve the partnership the words "of the first money taken out of the ground" were held to mean the first money taken out of the ground to which the grantee was entitled, which would be one-fourth of the amount so taken, or the gross amount to which the grantee would be entitled and not the net proceeds, and where it appeared that the aggregate gross amount was $26,038.30, the grantee is entitled to have one-fourth thereof, or $6,509.57, applied to the $24,000 deferred payment. But as the business of the firm resulted in a deficit the adjustment had to be apportioned in the payment of the indebtedness of the firm, and where it appeared that the total indebtedness was $19,314.94 the original grantee was held liable to the amount of $10,628.76.

Lesamis v. Greenberg, 225 Federal, 449, p. 450, August, 1915.

RIGHTS OF PARTNERS ON DISSOLUTION.

On the sale of assets of a partnership the partners will share equally in the proceeds and be entitled to have the same applied in that proportion to their indebtedness to the firm and the adjustment in the end must be on the basis of an equal division of the partnership property; and mining claims held by three persons at the time of making an agreement with a fourth, by which he should become a partner with a one-fourth undivided interest in all the mining properties then owned or to be acquired, and pursuant to which agreement the three persons conveyed to the fourth the undivided one-fourth interest in the mining property, became partnership property, and they are subject to the partnership indebtedness as partnership assets.

Lesamis v. Greenberg, 225 Federal, 449, p. 452.

MINING LEASES.

LEASES GENERALLY—CONSTRUCTION.

PRACTICAL CONSTRUCTION—INTENTION OF PARTIES.

When the terms of a coal lease are doubtful or capable of two different interpretations, the meaning put on the instrument by the parties themselves may be shown and will be enforced by the courts, as their interpretation of the instrument is strong evidence of being the correct one and expressive of the intention of the parties when executing the contract; but if the contract is not ambiguous or uncertain in its terms, and the intention of the parties as disclosed by its provisions is not doubtful, then the construction acted upon by the parties is not controlling and will not be enforced by the courts.

Tustin *v.* Philadelphia & Reading Coal & Iron Co. (Pennsylvania), 95 Atlantic, 595, p. 599, July, 1915.

INTEREST IN REAL ESTATE—SALE OF OIL WELL FOR TAXES.

An oil and gas lease or contract conveyed an interest in the land where the lessee had completed producing wells, and the wells so drilled, with the machinery attached, must be considered real estate and not personal property, and can not be sold for taxes as personal property. This proposition is on the theory that while oil and gas leases differ from ordinary leases and usually give the lessee the right only to explore the land for oil and gas (and until he finds either one or the other he has no interest in the land), but if the lessee finds oil and gas then his so-called lease has ripened into an interest in the land.

Johnson *v.* Sidney (Indiana Appeals), 109 Northeastern, 934, p. 935, October, 1915.

COAL LEASES.

LIABILITY UNDER LEASE—MISTAKE OF LAW.

A coal lessee accepting a lease of four small tracts to mine coal and pay a certain stipulated royalty per ton for all the merchantable coal mined and removed and a fixed minimum cash rental of a certain stated amount per annum during the continuance of the lease can not refuse to pay the stipulated royalty on the ground of a mistake in reliance upon the lessor's ownership of one of the four tracts, and that by reason thereof more coal had been paid for than

was under the other three tracts, where all the facts concerning the disputed title were of record when the lease was made, and the mistake, if there was a mistake, was a mistake of law and not of fact.

Clark v. Lehigh & Wilkes-Barre Coal Co. (Pennsylvania), 95 Atlantic, 462, July, 1915.

TITLE TO LEASED TRACTS—MISTAKE AS TO ONE TRACT.

A lease of coal lands granted to the lessee all the coal underlying four contiguous pieces of land separately described, the lessee to hold the premises until he should have mined and removed therefrom all the merchantable and mineable coal, and to pay a stipulated royalty per ton thereon with a fixed minimum cash rental, such cash rental to be paid by royalties. The lessee after operating the premises for 20 years and mining and removing coal from all four of the demised tracts, paid the lessor all fixed cash rentals and royalties as they accrued; and the lessee while continuing to mine coal from the premises, and while all the merchantable and mineable coal had not been mined, refused payment of royalties and of rentals on the ground that the title and ownership of the fourth tract described in the lease was not in the lessor, but was in fact in the lessee, and that the lessee, believing and relying on the title and ownership by the lessor, had through accident and mistake paid more for coal than was in the other three tracts of land and was therefore under no obligation to pay the lessor for additional coal mined, but the lessee was entitled to reimburse himself for such overpayments from those tracts which the lessor did in fact own. Granting that the title to the fourth tract was in the lessee at the time of the execution of the lease, yet the mere fact that the lessee took the lease is not sufficient of itself to show that there was any mistake as to the title at the time the contract was executed; and as the leased property consisted of four small contiguous pieces of coal claimed by the lessor, none or not more than one of which was large enough for a coal operation, the lessor manifestly would desire to let the coal under the four pieces if at all, as working the smaller tracts as a separate operation would not be practicable. The court must assume, in the absence of a showing, that it was more than probable that the question of the title was disclosed, and while the lessee may have asserted title yet he agreed to take the lease as a compromise of any conflicting claims because of the advantages that would accrue therefrom; and after the lapse of 20 years, during which time the lessee has operated the coal and paid the rental, direct and satisfactory proof of the alleged mistake must be produced before a court of equity would relieve the lessee from the payment of the stipulated royalties.

Clark v. Lehigh & Wilkes-Barre Coal Co. (Pennsylvania), 95 Atlantic, 462, July, 1915.

CONSTRUCTION—ROYALTIES—RIGHT OF WAY CHARGES.

A coal lease obligated the lessee to pay the lessor as rent a graduated rent beginning with a certain stated rate per ton for large and prepared sizes and down to a smaller stated sum for coal dirt, mined and carried away or shipped from the demised premises, the rent increasing after a certain stated date. The lease contained a further obligation to pay a rent or right of way of 5 cents per ton on all coal mined from adjoining lands and carried through the demised premises, to be paid at the same time and in the same manner as the payment of rents on the coal mined. The lease obligated the lessee to mine and ship at least a certain stated number of tons of coal each month, payment of rents thereon to be made on the 15th of each succeeding month, such sum of money when added to the rents accrued during such month to be equal to a certain stated sum, and providing that any excess of rents for any month may be applied to a deficit for a succeeding month. The word "rents," as used with reference to the coal mined and shipped is construed as including the rent or royalty on coal mined from the leased premises, and does not include the right of way charge as part of the minimum royalty payable each month; and the lessee was required to pay the right of way charge in addition to the minimum monthly royalty; and when the lessee failed to mine the stipulated number of tons in any month it was required to pay the difference between the royalties on the coal actually mined and the minimum royalty fixed by the lease, and also to pay the right of way charge for coal carried through the leased premises.

Tustin v. Philadelphia & Reading Coal & Iron Co. (Pennsylvania), 95 Atlantic, 595, p. 597, July, 1915.

PURCHASE OF LEASE INDUCED BY FRAUD—ABATEMENT IN PRICE.

A coal-mining company is entitled to an abatement of the purchase price to the extent of the actual value of the property, where it was induced to purchase a mining lease by the false and fraudulent representation of a person interested in the lease and who was to and did receive the consideration for such lease, and who falsely represented that the coal in the leased mine was very low in ash and guaranteed that it was 25 per cent better than certain coals well-known to the purchaser, and furnished the purchaser an analysis showing that the coal contained but a comparatively small percentage of ash, when in truth and in fact the coal contained from 2 to 2½ times as large a percentage of ash as the other named coals, and where the mining company relied upon the representations, purchased the coal lease, and thereafter operated the mine and mined and sold the coal, and where the representations as to the quality of the coal were false and the

coal was not of the quality represented, but was greatly inferior in grade and could not be sold in the market as coal of the quality as represented, and by reason of the high percentage of ash in the coal it was practically impossible to market the product of the mine, and the value of the property was greatly less on account of the quality of the coal and was not in fact worth half as much as it would be if the coal were as represented.

Consumers' Fuel & Coal Co. *v.* Yarbrough (Alabama), 69 Southern, 897, p. 899, October, 1915.

OIL AND GAS LEASES.

CONSTRUCTION OF LEASE—TIME AS ESSENCE OF CONTRACT.

The fact that the statute of Oklahoma provides that time is never considered as the essence of a contract, unless by its terms expressly so provided, does not mean that time is never the essence of a contract unless these particular words are used in it, but if it appears from the provisions contained in a contract that it was the intention of the parties that time should be of the essence thereof, then it is within the reason of the statute.

Mitchell *v.* Provost (Oklahoma), 152 Pacific, 597, p. 599, October, 1915

NATURE AND CONSTRUCTION.

An agreement in the form of a lease for a limited term of years granting the right to explore for oil and gas and to retain that found and extracted is of a peculiar class, and the interest acquired by the lessee is more in the nature of a license than an estate in the land itself.

Mitchell *v.* Provost (Oklahoma), 152 Pacific, 597, p. 599, October, 1915.

UNILATERAL CONTRACT.

Oil and gas leases usually lack the mutuality essential to their validity, and a unilateral executory contract is in law a nudum pactum and unenforceable; and where such a contract is left to one of the parties to choose whether he will proceed or abandon it, neither can specifically enforce its execution in equity. Generally such leases of land for the exploration and development of oil or gas or other minerals are executed by the lessor in the hope and upon the condition, either express or implied, that the lands shall be developed for the minerals contemplated; and it would be unjust and unreasonable and would contravene the nature and spirit of the lease to permit the lessee to continue to hold under it any considerable length of time without making any effort to develop the premises according to the express or implied purpose of the lease.

Soaper *v.* King (Kentucky), 180 Southwestern, 46, p. 47, November, 1915.

OPTIONAL PROVISION—CONSTRUCTION AND CANCELLATION.

An oil and gas lease containing a provision to the effect that if a well is not drilled on the leased premises in one year from date, then the lease and agreement shall be null and void, unless the lessee within each and every year in advance, after the drilling of a well, shall pay a certain stipulated rental per acre for the first year, amounts to an option only and gives the lessor the right to cancel the agreement unless the conditions are complied with and such optional agreements are strictly construed in favor of the party that is bound and against the party that is not bound.

Mitchell *v.* Provost (Oklahoma), 152 Pacific, 597, p. 599, October, 1915.

LEASE AS INTEREST IN LAND—ASSIGNMENT—STATUTE OF FRAUDS.

Oil and gas are minerals and are a part of the realty, and a lease giving to the lessee the right to explore certain lands and remove therefrom the oil and gas is a contract for the transfer and sale of an interest in land and is required to be in writing; and as the lease itself is required to be in writing, so the assignment thereof must also be in writing, and a parol assignment of such a lease is within the statute of frauds.

Beckett *v.* Iseman Oil Co. (Kentucky), 178 Southwestern, 1084, September, 1915.

ACTION TO RECOVER ROYALTIES—PARTIES.

In an action by a lessor against the lessee for an accounting of royalties on oils produced under an oil and gas lease and where it is averred that the lessee after the execution of the lease assigned one-half thereof to a named third person, it is necessary that such third person be made a party in order that all rights might be litigated in the one suit.

Gardner *v.* South Penn Oil Co. (West Virginia), 86 Southeastern, 560, September, 1915.

LEASE FOR OIL DOES NOT INCLUDE GAS.

An oil and gas lease executed upon a certain stated consideration provided further that the lessee was to pay to the lessor a certain stated sum within 90 days after a well for oil and gas is drilled and oil produced in a pipe line in paying quantities, and to pay a like sum within 90 days after each paying well thereafter is drilled until the payments amount in all to a certain stated sum, does not require the lessee to pay the stated sum where a well was drilled on the premises which produced gas only.

Ball *v.* Freeman (West Virginia), 87 Southeastern, 91, November, 1915.

DRAINING ADJOINING LANDS—RIGHT TO ACCOUNTING.

While oil wells drilled and operated may, by reason of their proximity to a division line, in fact drain oil from adjoining lands, yet

such operations, in the absence of special circumstances or relations between the parties, offer no basis for a claim to a share in or an accounting for the oil so produced, or for a receivership for the operation of the wells so drilled.

Gain v. South Penn Oil Co. (West Virginia), 86 Southeastern, 883, p. 885, October, 1915.
See Fairbanks v. Warrum (Indiana Appeals), 104 Northeastern, 983, p. 986.

DRILLING NEAR LINE—FRAUD NOT IMPUTABLE.

A lessee who obtained an oil and gas lease from the owner of land and who was unable to obtain a lease from the adjoining landowner, is not to be charged with fraud by the latter and is not liable to such adjoining landowner for any part of the oil produced by him from wells on the leased land, though located so near the line as to drain the oil from the adjoining premises, and the mere execution of such a lease causes no inference of a fraudulent intent and justifies no implication of a purpose on the part of the lessee to wrong the adjoining landowner.

Gain v. South Penn Oil Co. (West Virginia), 86 Southeastern, 883, p. 885, October, 1915.
See Fairbanks v. Warrum (Indiana Appeals), 104 Northeastern, 983, p. 986.

FORFEITURE OF OIL AND GAS LEASE FAVORED.

While the general rule is that forfeitures are not favored by the law, yet forfeitures on the part of lessees in oil and gas leases, which arise by reason of the neglect of the lessees to develop or operate the leased premises, are favored by the law because of the peculiar character of the product to be produced.

Mitchell v. Provost (Oklahoma), 152 Pacific, 597, p. 599, October, 1915.

Forfeitures generally are not favored by the law, but forfeitures which arise in gas and oil leases by reason of the neglect of the lessee to develop or operate the leased premises are rather favored because of the peculiar character of the product to be produced, and in such cases it is necessary to guard the rights of the landowner as well as public interests by numerous covenants, some of the most stringent kind, to prevent other lands from being drained by unexecuted and profitless leases incompatible with the rights of alienation and the use of the land; and so forfeiture for nondevelopment or delay is essential to profit and public interests in relation to the use and alienation of properties and prompt performance of contracts so essential to the rights of the parties, or delay by one party likely to prove so injurious to others, is perhaps found in no other business. However, if the lessor accepts the annual rentals the contract will be perpetuated, but he may at the end of any rental period decline to accept rent and require the lessee to begin operations for oil or gas.

Soaper v. King (Kentucky), 180 Southwestern, 46, p. 47, November, 1915.

RIGHT TO RENTALS—FORFEITURE.

Under an oil and gas lease the lessee agreed to commence a well on the premises within 90 days from the date or to pay the lessor 25 cents per acre at the end of each three months thereafter or forfeit the lease, but the completion of such well should be a full liquidation of all rentals during the remainder of the term; and it further provided that the lessee should at any time upon the payment of $1 reassign the lease to the lessor and be released from all conditions imposed, but if any rentals were due at the time the same should be paid to the date of reassignment, and upon the failure of the lessee to commence a well within the stated time, or pay the specified rents or reassign the lease according to its terms, the lessor may at his option declare the lease forfeited, or sue for the rentals under the lease.

Lamar *v.* Farmer (Indiana Appeals), 109 Northeastern, 791, October, 1915.

FAILURE TO DEVELOP—RIGHT OF LESSOR TO CANCEL.

An oil and gas lease covering a large tract of land for a nominal consideration and the further agreement of the lessee to pay the lessor one-eighth of all the net proceeds arising from the sale of oil and gas or other mineral, the lease further reciting that the rights and exclusive privileges were granted in consideration that the lessee should begin in good faith to drill one or more wells on some part of the land within two years from the date of the lease, and upon failure so to do the lease should be void, may be forfeited by the lessor after the expiration of the two years where the lessee did no more than drill a well upon the leased premises to a depth of about 200 feet, and found a vein of coal, but work in the development of the land ceased with the discovery of the coal, though the lessor never demanded or notified the lessee that the lessor desired or required that the coal and minerals underlying the leased lands should be mined and developed.

Soaper *v.* King (Kentucky), 180 Southwestern, 46, November, 1915.

EFFECT OF SURRENDER CLAUSE—SPECIFIC PERFORMANCE.

A surrender clause in an oil and gas lease which gives to the lessee the right at any time to surrender and terminate the lease, after which all payments or liabilities should cease and terminate, deprives the lessee of the right of specific performance, directly or indirectly, until he has performed the contract or placed himself in such a position that he might be compelled to perform it on his part.

Hill Oil & Gas Co. *v.* White (Oklahoma) 151 Pacific 1051 p. 1052 (October, 1915).

MINING PROPERTIES.

TAXATION.

CORPORATION TAX—CORPORATION IN HANDS OF RECEIVER.

Section 5506 of the General Code of Ohio refers to fees, taxes, and penalties required to be paid only by corporations doing business, and does not intend that a receiver shall pay such fees, taxes, and penalties, as the penalties are required to be paid only by corporations doing business, and the purpose of the statute is to fix a lien for the payment of the tax by the corporation required to pay it upon the property employed in the transaction of its business or in the hands of a receiver, or if the property has gone into the custody of a court of equity through its receiver, and the receiver must recognize the lien of the statutes upon the assets in his hands for the tax of a preceding year imposed upon the corporation when it was doing business; but this section of the statute does not impose a tax when the reason for the tax and its only justification no longer exist. This construction of this section reconciles it with the other sections of the statute on the same subject, which the court is bound to effect if possible, and brings about a result not only equitable, reasonable, and just, but also in consonance with the clear intention of the legislature to impose a tax upon the right granted by the State to be a corporation and to continue to do business as such.

Keeney *v.* Dominion Coal Co., 225 Federal, 625, p. 627.

METHODS OF DETERMINING VALUE.

Where in the valuation of coal lands by county commissioners for the purpose of taxation it appears that the rules applying to coal lands and improvements thereon were properly applied, the valuations as fixed by former assessors, commissioners, the coal tax commission, and the witnesses, will not be disturbed on appeal when considered in connection with the depreciation from exhaustion, as well as the enhancement from the advance in the price of coal and the general increase in value of coal lands as shown by the evidence.

Philadelphia & Reading Coal & Iron Co. *v.* Commissioners of Northumberland County (Pennsylvania), 96 Atlantic, 406. May, 1915.

METHOD OF FIXING VALUE—PRESUMPTION—EVIDENCE.

In the taxation of mining property the taxing authorities make out a prima facie case by the introduction in evidence of the assessment of record in the office of the county commissioners as provided by the board of revision, with such other books and data as may be on file relating to the valuation of the mining property in question. This method of procedure is based upon the presumption that public officers do their duty and have done so in fixing the valuation of mining property for taxation the same as in the performance of other official acts. But this presumption may be rebutted by evidence showing that the official acts complained of were not in compliance with what the law requires in the performance of a particular official duty; and if the evidence shows that the board of revision acted arbitrarily, or without sufficient reliable information and evidence, or without substantial bases to justify their decision, a prima facie case based upon such a presumption is rebutted, and should be so treated by the chancellor, who must determine questions in controversy in the light of the evidence offered and admitted at the hearing.

Lehigh Valley Coal Co. *v.* Northumberland County Commissioners (Pennsylvania), 95 Atlantic, 712, July, 1915.

VALUES DETERMINED ACCORDING TO EVIDENCE.

Tax assessment cases should be heard and decided as other cases of similar character brought before a judicial tribunal, and courts in fixing the value of mining properties can not ignore or disregard the rules of procedure and fix the valuation, not upon the weight of the evidence produced, but rather upon the general information of court and counsel. The weight of the evidence as to such values should be decisive with the court, and the burden is always on the litigants to introduce the evidence relied on to support their respective contentions, and it is not for the court to fix the valuation of such properties at what he as an individual might think them worth, but his conclusions should be based upon the evidence introduced by the parties, and it is the duty of a court to consider conflicting evidence and decide the issue involved, having due regard to the weight of the evidence.

Lehigh Valley Coal Co. *v.* Northumberland County Commissioners (Pennsylvania), 95 Atlantic, 712, p. 714, July 1915.

INDEPENDENT USE OF MINING CLAIM—SURFACE AND MINERALS.

Under the statute of Utah (Laws of 1907, section 2504) mining claims as such may be assessed at the specific valuation affixed by the statute, while the surface ground if used for other than mining

purposes, and if it has a value separate and independent from mining claims as such, may also be assessed separately and distinct from the mining claim; and if a person is in actual and adverse possession of the surface ground of a mining claim, for the period of time required by the statute and has during that time improved the surface under a claim of right, such person may be assessed with the surface area and the improvements thereon; and the payment of taxes by him will be sufficient to entitle him to make a claim of adverse possession to the surface thereof together with the improvements thereon, as against the owner of the mining claim, though the latter may have paid the taxes on the mining claim as such and in accordance with the fixed valuation thereof and may claim all the minerals beneath the surface.

Utah Copper Co. *v.* Eckman (Utah). 152 Pacific, 178. p. 180, October, 1915.

FINDING AS TO PAYMENT OF TAXES BY SURFACE AND MINERAL OWNER.

While under an allegation of general ownership a party, either plaintiff or defendant, may prove the character of such ownership by proving adverse possession and payment of taxes, yet however general the pleadings in that regard may be in case the surface ground of a mining claim is not questioned, the evidence and findings upon the question of payment of taxes should be direct and specific and it should be found whether merely surface possession together with improvements is claimed, or whether the title to the whole claim is asserted; and in either event the assessment and payment of taxes should be shown and found so that a court may determine the relative rights of the surface and mineral owners.

Utah Copper Co. *v.* Eckman (Utah), 152 Pacific, 178, p. 180, October, 1915.

ASSESSMENT OF OMITTED PROPERTY—DECISION OF JUDGE.

Proceedings of revenue agents to cause mining property in the nature of a mining lease to be listed for taxation, which has been omitted by the owners, the assessors, or the boards of supervisors, are special proceedings provided for by the statute and the judge of the county court acts in a ministerial capacity and as such is the only one of the agencies provided by law for assessing such property for taxation; but his judgment is the judgment of a court and to the extent of determining whether property has been assessed or omitted and its value, he acts judicially, and the same rule applies to the circuit court upon an appeal from a judgment of the county court.

Stearns Coal & Lumber Co. *v.* Commonwealth (Kentucky), 179 Southwestern, 1080, p. 1082, November, 1915.

ASSESSMENT OF OMITTED PROPERTY—TRIAL BY JURY.

In proceedings of revenue agents under the statute of Kentucky before the county court with the right to appeal to the circuit court, for the assessment and taxation of omitted mining property, a trial by jury is not contemplated, and the property owner is not entitled to such a trial.

Stearns Coal & Lumber Co. *v.* Commonwealth (Kentucky), 179 Southwestern, 1080, p. 1082, November, 1915.

STATUTORY LIENS.

ENFORCING MINER'S LIEN—PLEADING.

A complaint to foreclose a lien of a miner for services performed by him in a mine is sufficient where it alleges that he was employed by the duly authorized agent of the mining corporation and began work upon the property as an underground miner, with pick and shovel and other usual tools used in such work, and that he performed a certain stated number of days' labor at an agreed wage of a certain stated price per day, thereby earning a stated total sum and of which there was due him a certain stated amount from the mining company; that such labor and services were done and performed in the working, development, and operation of the mining property described and were for the benefit of such property; and on a certain stated day he did, for the purpose of securing and perfecting a lien for the money due him under his contract, file and cause to be recorded in the office of the county clerk his claim and notice of lien duly verified by him; that such claim and notice contained the name of the lien claimant, a true statement of his claim and demand after deducting all just credits, the name of the owner and reputed owner of the mining property, and the name of the person by whom the claimant was employed, a true statement of the contract under which such services were performed, a description of the property charged with the lien sufficient for identification, and which claim and lien were verified by the oath of the claimant; and that said claim of lien has not in any way been satisfied or discharged, and the same is now a valid subsisting lien upon such property.

Haines Commercial Co. *v.* Graville (Oregon) 152 Pacific, 877, p. 878, November, 1915.

MINER'S LIEN—SUFFICIENCY OF STATEMENT.

Under the statute of Oregon a miner in his notice of lien is not required to segregate his demand for overtime work from the amount due under his contract of employment; but he is required only to make a true statement of his demand after deducting all just credits and offsets.

Haines Commercial Co. *v.* Graville (Oregon), 152 Pacific, 877, p. 879, November, 1915.

MINER'S LIEN PRIOR TO MORTGAGE.

The amendatory act of 1907 of Oregon, providing for liens in favor of persons performing labor in or upon any mine or mining claim, gives such liens a priority over all other claims and liens, and is superior to mortgages; and a mortgagee accepting a mortgage subsequent to such amendatory act is not deprived of his property right without due process of law, because his lien would be postponed to the liens of such laborers.

Haines Commercial Co. v. Graville (Oregon), 152 Pacific, 877, p. 879, November 1915.

DAMAGES FOR INJURIES TO MINERS.

ELEMENTS OF DAMAGES.

FUTURE SUFFERINGS.

In an action by a miner for damages for injuries caused by the negligence of the mine operator, where it appears from the evidence that the miner will continue after the trial to endure sufferings from his injuries, he may recover therefor, regardless of whether there is permanent impairment of earning power pleaded or proved.

Moses v. Proctor Coal Co. (Kentucky), 179 Southwestern, 1043, p. 1044. November, 1915.

DAMAGES EXCESSIVE.

INSTANCE.

A verdict of $2,000 in favor of a miner who received a shock by coming in contact with an electric wire carrying 250 volts is grossly excessive where the miner was able to return to his work on the day on which he received the injury, and after being absent the next day returned and worked the two succeeding days, and was then confined to his bed about three weeks, but where the evidence showed that the injuries of which he complained were not attributable to the shock he received but to other causes.

Imperial Jellico Coal Co. v. Neff (Kentucky), 179 Southwestern, 829, p. 830, November, 1915.

INTERSTATE COMMERCE.

TRANSPORTATION OF COAL—COMPETITION AND RATES.

Competition for carriage of the same anthracite coal does not usually exist, as each carrying company has its own tributary mines, and because of topographical conditions these are not reached by any other carrier. The coal is mined and brought to the surface and prepared for market at the mines, and is there loaded upon the cars of the carrier that serves the particular mine, and is then sent forward either to its ultimate destination or to barges that complete the carriage when water transportation is necessary or desirable. Accordingly, the competition is in the markets, and it would be idle for one carrier to attempt to interfere with the traffic of a rival. While carriers might combine to fix rates at an oppressive sum, yet in the absence of such a charge the question whether a rate is exorbitant is to be determined by the Interstate Commerce Commission and not by the courts.

United States v. Reading Co., 226 Federal, 229, p. 263.

LEASE AND LIMITATIONS ON SHIPMENT OF COAL—UNLAWFUL RESTRICTIONS.

A lease provided that a certain railroad should pay as rental one-third of the gross receipts of another railroad company and provided that all the coal mined by a certain-named mining company on its own lands should be sent to market over the roads of the two railroad companies named, "when destined to points or markets reached by said roads; and, when destined for markets not so reached, it shall be sent as far as practicable over the said road." But this covenant in the lease did not apply to one-fourth of the coal mined by the mining company in a particular-named region and this might be sent to any market not reached by railroad lines running in a certain direction and to certain markets. The provisions of the lease were subsequently modified to the effect that when one-third of the gross receipts should fall short of a certain stipulated amount, the lessee should make up the deficiency; but when one-third of such gross receipts should exceed another and a larger stated sum, then the coal company should relinquish any claim to the excess. Still later

another change was made permitting the one-fourth referred to in the lease to be sent to market over lines other than that of the railroad company mentioned and its branches, if by so doing the mining company could realize a larger profit than could be realized if coal were shipped over the railroad named. These provisions and covenants do not impose unlawful restrictions on the coal company's shipments as the covenants relate to the shipment of coal in the direction of the best markets for the particular coal named and the company has plenty of coal available for the market in other directions, but for reasons of economy it prefers to restrict its shipments in the one particular direction, and this restriction is voluntary, and is due to the fact that its coal can be sold elsewhere to better advantage. While the interests of the coal company are best advanced by shipping a large proportion of its coal to markets reached by the railroad named, the coal company does not regard itself as absolutely bound to ship three-fourths of its output over such road, and the coal company's production has not been diminished by reason of such restrictions, but has largely increased.

United States v. Reading Co. 226 Federal, 229, p. 264.

COMBINATION OF COAL COMPANY AND RAILROAD COMPANY NOT ILLEGAL.

The ownership of coal lands and the business of coal mining, and the use of a railroad to get coal to market, are all lawful. Under such circumstances the railroad company and the coal company are not competitors but each performs its own function in putting a useful article in the hands of consumers. The fact that a coal company is a large producer of coal, and therefore a large seller and shipper, is not in itself an offense against the Sherman antitrust statute; but in some aspects it may be regarded as a merit, for the more coal the company produces the more extensive would be its operation, thus benefiting labor and the merchants that furnish supplies to the mines, and the larger would be the quantity at the consumers' command; and under such circumstances a combination of the coal company and the railroad company, through the medium of a holding company owning the stock of both, is not necessarily a violation of the antitrust act, unless unlawful methods or practices are resorted to, which tend to restrain competition and create a monopoly.

United States v. Reading Co., 226 Federal, 229, p. 268.

MINING AND SELLING LARGE QUANTITIES OF COAL NOT AN OFFENSE.

The fact that the coal-land holdings of a coal company are large and that the coal company ships and sells the largest percentage of all the anthracite coal that reaches the market, is not alone sufficient

to constitute an offense against the Sherman antitrust act, in the absence of any showing of harm or injury. Under such circumstances but three classes of persons could be injured: (1) Rival producers on a large scale, who might be injured by unfair methods of competition; (2) smaller producers, who might suffer by similar methods; and (3) the consumer, who might suffer by extortionate prices. But in the absence of proof that either of these classes of persons has sustained injuries, the charge of unlawful competition or restraint necessarily fails.

United States v. Reading Co. 226 Federal, 229, p. 268.

COMBINATION OF COAL COMPANIES BY HOLDING COMPANY UNLAWFUL.

A combination by which a holding company, already the owner of the capital stock of a railroad company and of a coal company, purchased the majority stock in another railroad company which owned practically all the stock of another coal company, where it appears that the two railroads have been carrying anthracite coal of these two large producers to the same markets where the coal has been sold in competition and where it appears that these two carriers transport practically one-third of the total tonnage of anthracite coal carried by the railroads that reach the anthracite field, and the two coal companies dispose of more than 20 per cent of all the anthracite coal sold on the market, is a union of the two companies in the same ownership that creates a combination in restraint of interstate trade in violation of the Sherman Antitrust Act.

United States v. Reading Co., 226 Federal, 229, p. 271.

INTERSTATE CARRIAGE OF COAL—SINGLE OWNERSHIP OF RAILROAD AND COAL COMPANY.

The act of 1906 (34 Stat. 585) does not forbid a railroad company holding stock in a coal-mining corporation, if such corporation be a bona fide organization; and coal mined and produced by such a corporation may be lawfully carried by a railroad company although such railroad company is a stockholder in the mining corporation; and this is true without regard to the extent of the railroad's stock ownership, whether a part or the whole; but under such circumstances the railroad company must not use the power given by such ownership to obliterate the distinction between the two organizations and must not exert its power so as to commingle indistinguishably the affairs of both and thus cause the two corporations to be one for all purposes and it must not destroy the entity of the producing or mining corporation and thus make the two virtually one; and if it actually do these forbidden things, then the commodities clause

applies and condemns as unlawful such abuse of a lawful right. The fact that the capital stock of a railroad company and of a coal company was owned by a holding company and the coal mined by the mining company was carried by the railroad company is not an offense against the commodity clause of the statute where it is made to appear that the railroad company did not mine or produce the coal transported for the coal company, and where the railroad company did not own or have any interest, direct or indirect, in the coal transported.

United States *v.* Reading Co., 226 Federal, 229, p. 273.

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Bulletin 119

DEPARTMENT OF THE INTERIOR

FRANKLIN K. LANE, SECRETARY

BUREAU OF MINES

VAN. H. MANNING, DIRECTOR

ANALYSES OF COALS

PURCHASED BY THE GOVERNMENT DURING THE FISCAL YEARS 1908–1915

BY

GEORGE S. POPE

WASHINGTON
GOVERNMENT PRINTING OFFICE
1916

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By GEORGE S. POPE.

INTRODUCTION.

The Government of the United States annually expends approximately $8,000,000 for coal. Prior to 1906, this coal was purchased mainly on its reputation, or trade name, rather than under contracts specifying the heating value of the coal, its contents of ash and moisture, and other characteristics. In recent years the Government and other large consumers have appreciated more and more the desirability of definitely determining by chemical analyses and tests the character and quality of coal deliveries. Studies of engine-room and boiler-room efficiencies and economies point forcibly to the necessity of devoting more thought to the improvement of the boiler-room end. This calls for an intimate knowledge of the character and quality of the fuel used. The analyses and tests of delivered coal furnish such data, whereby the power-plant results can be comprehensively studied and a continuous check maintained on the coal and on the conditions of plant operation.

Under authority of acts of Congress making appropriations for analyzing and testing fuels belonging to or for the use of the United States Government, a laboratory is maintained at the headquarters of the Bureau of Mines, Washington, D. C., where samples representing deliveries of coal purchased for Government use are analyzed and tested.

The Bureau of Mines has been active in promoting the purchase of coal by the Government under specifications,[a] that is, by contracts that make definite requirements regarding the heating value of the coal expressed in British thermal units, and the composition as shown by proximate analysis. Under many of these specification contracts the bidders guarantee the quality of the coal offered, and that guaranteed by the successful bidder becomes the standard of his contract. The deliveries are sampled and analyzed to determine whether the coal is of the quality guaranteed by the contractor, and if it is not, the price to be paid is decreased in proportion; but if the coal is of higher quality, the price is proportionately increased.

The analyses of coals or the guaranties offered by the bidders may in some cases be used for determining the award of a contract, but if the coals offered are of widely different characteristics, it may be difficult to determine which would prove the cheapest fuel, without

[a] For types of specifications and methods of sampling, see Pope, G. S., Methods of sampling delivered coal and specifications for the purchase of coal for the Government: Bull. 116, Bureau of Mines, 1916, 64 pp.

having their relative evaporative efficiencies. Hence, it may be necessary to conduct evaporative tests under service conditions in order to determine which coal is particularly adapted for successful and economical use in the plant. But once a particular coal is selected, regardless of the procedure of determining the award of a contract, then the greatest advantage of the specification method is realized, in that it guarantees to the purchaser coal of uniform character and quality, thereby insuring the best results in the plant.

The cost of purchases, under such specifications, of fuel for the use of the Government now aggregates approximately $4,100,000 per annum, and the cost of additional fuel for which samples are taken and submitted to the Bureau of Mines for analysis in order to determine the character and quality of the coal furnished aggregates some $3,000,000 per annum more. In fact, information is now obtained regarding the quality of fuel purchased on almost all contracts large enough to warrant sampling and analysis and heating-value tests.

It may be said that the purchase of coal under specification is still in the stage of evolution and development, and that experience and time will be required to develop fully standard specifications and methods of sampling and analysis that may be used universally. The success of the specification method for the purchase of coal and the reliability of analysis now rests almost entirely on sampling.[a] Improper sampling leads to controversies, with resulting condemnation of the specification method in general and the value of laboratory analyses and tests in particular.

A number of bulletins[b] have been published showing the results of the purchase of coal by the Government under specifications. This bulletin is a compilation of the results of coal analyses by the Government, including those made in the fiscal years 1908–1910, which have been previously published, and later analyses representing coals analyzed during the fiscal years 1911–1915. The preceding bulletins gave individual analyses or average monthly analyses, whereas this bulletin gives the average analyses only for the entire contract. It is hoped that this compilation of a series of comparable analyses of the coals purchased by the Government will be of value alike to coal dealers, to Government engineers, to purchasing agents, and to all users of coal.

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[a] See Pope, G. S., Loc. cit.

[b] Randall, D. T., The purchase of coal under Government and commercial specifications on the basis of its heating value, with analyses of coal delivered under Government contracts: U. S. Geol. Survey Bull. 339, 1908, 27 pp.; Burrows, J. S., Results of purchasing coal under Government specifications: U. S. Geol. Survey Bull. 378, 1909, 44 pp.; Pope, G. S., The purchase of coal by the Government under specifications, with analyses of coal delivered for the fiscal year 1908–9, Bull. 11, Bureau of Mines (reprint of U. S. Geol. Survey Bull. 428), 80 pp.; Pope, G. S., Government coal purchases under specifications, with analyses for the fiscal year 1909–10, with a chapter on the fuel-inspection laboratory of the Bureau of Mines, by J. D. Davis: Bull. 41, Bureau of Mines, 1912, 97 pp.

The analyses given herein are of samples taken from commercial deliveries. In making a comparison of analyses of commercial shipments with analyses of samples collected from the face of the bed in the mine, due allowance must be made for the larger proportion of impurities that may be included in the commercial operation of the mine. It is difficult to take a mine sample in which the impurities are rejected in exactly the same manner as is done by the miner.* The practice of different miners will vary, especially if rigid inspection at the tipple is not enforced. In some mines, for instance, where the coal bed has friable partings or has a soft, flaky roof or floor, the inclusion of some foreign matter is unavoidable. Hence, the analysis of the mine sample usually indicates a better grade of coal, as regards ash content and heating value, than the actual commercial shipments, and for this reason the mine sample should be considered as representing the coal that can be produced under only the most favorable conditions of mining and preparation.

In commercial shipments that are sampled at their destination the moisture content may be either more or less than that in the mine samples, the relative proportions depending on the amount of bed moisture, the size of the coal, and the weather conditions during transit.

Analyses representing many shipments and a large tonnage more truly indicate the general quality of a particular coal than does a single analysis from a specially prepared shipment, or analyses of carefully selected mine samples.

ACKNOWLEDGMENTS.

The analyses presented in this bulletin were made and compiled by the fuel-inspection section of the bureau, which is under the general supervision of O. P. Hood, chief mechanical engineer, with the writer in immediate charge of the section. The work of the section includes the sampling, analyzing, and testing of coal purchased for Government use. The collection of samples* was in charge of P. M. Riefkin, engineer, assisted by N. H. Snyder, assistant engineer; D. M. Obler, J. B. Riefkin, Royce L. Beers, Max M. Shaw, and E. M. Kearney, junior engineers, and J. J. Conard, skilled laborer. J. D. Davis, chemist in charge of the analytical laboratory, was assisted by H. M. Cooper, assistant chemist; E. L. Wallace, G. Bornscheuer, I. M. Bortman, O. Christie, A. Engel, J. G. Fairchild, W. A. Gonzalez, W. J. Buttner, J. Cullen, W. Freeman, A. S. Thatcher, H. G. Elledge, M. J. Ingle, D. C. Smith, J. P. Bader, B. D. Watts, P. J. Donk, K. J. Osterhout, and J. Norton, junior chemists; O. Ratz, junior computer; H. A. Goodman, skilled laborer; J. W. Peters and J. C. White, expert computers, all of whom contributed to

* The personnel given is of those who were employed continuously, as well as for various lengths of time during the fiscal years 1911–1915, inclusive.

the success of the work of analyzing and testing the coal purchased by the Government; acknowledgments are due also to C. H. Unger and J. P. Hirth for faithful and efficient clerical services.

TABULATED ANALYSES.

Table 1 shows the general averages by years of the several sizes of anthracite coal delivered to the Government.

Anthracite coal is graded into sizes before shipment, and each size commands a certain price. The size of the openings in screens and the types of screens used in preparing the sizes may vary slightly. However, the following table indicates the commercial sizes of anthracite.

Sizes of anthracite.

Sizes.	Square mesh, inches.		Round mesh, inches.	
	Through.	Over.	Through.	Over.
Broken (furnace)	4	2¾	4½	3¼
Egg	2¾	2	3¼	2¼
Stove	2	1⅝	2¼	1½
Nut (chestnut)	1⅝	¾	1½	¾
Pea	¾	½	¾	⅜
Buckwheat No. 1	½	¼	⅜	⅜
Buckwheat No. 2, or rice	¼	⅛	⅜	⅜
Buckwheat No. 3, or barley	.....	.....	⅜	⅜

Table 2 gives the results of yearly average analyses of coal, except the Pennsylvania anthracite, delivered for Government use during the fiscal years 1908–1915. The details regarding place of delivery, contract guarantees, and price per ton are given on pages 52 to 101. The number of pounds per ton is 2,240 unless otherwise stated.

It was not always possible to obtain complete information on the coals; hence in some cases columns 1, 2, 3, 4, and 5 of the table are not filled in completely. For some contracts the information furnished regarding the origin of the coals was very meager, and in such cases State mine inspectors' reports, commercial coal-mine directories, etc., were freely referred to and additional information obtained in order that the coals could be more fully described and their origin more definitely determined.

TABLE 1.—*General average quality of anthracite coal delivered to the Government, fiscal years 1907–1915.*

BROKEN (FURNACE).

Fiscal year.	Moisture, as received.	Ash, dry coal.	Heating value per pound.						Number of analyses averaged.
			As received.		Dry coal.		Moisture free and ash free.		
			B. t. u.	Calories.	B. t. u.	Calories.	B. t. u.	Calories.	
1906–7	4.08	10.44	12,861	7,146	13,408	7,449	14,971	8,318	14
1907–8	.....	10.00	.....	.....	.....	.....	.....	.....	270
1908–9	.....	10.73	.....	.....	.....	.....	.....	.....	276
1909–10	.....	10.14	.....	.....	.....	.....	.....	.....	302
1910–11	3.88	10.83	12,777	7,099	13,293	7,386	14,907	8,282	107
1911–12	.....	10.55	.....	.....	.....	.....	.....	.....	163
1914–15	3.87	11.11	12,782	7,102	13,297	7,388	14,959	8,311	13

TABLE 1.—*General average quality of anthracite coal delivered to the Government, fiscal years 1907–1915*—Continued.

EGG.

Fiscal year.	Moisture, as received.	Ash, dry coal.	Heating value per pound.						Number of analyses averaged.
			As received.		Dry coal.		Moisture free and ash free.		
			B. t. u.	Calories.	B. t. u.	Calories.	B. t. u.	Calories.	
1906–7	4.16	10.57	12,960	7,201	13,523	7,513	15,121	8,401	17
1907–8		10.83							187
1908–9		11.55							301
1909–10		11.37							373
1910–11	3.93	11.08	12,824	7,125	13,349	7,417	15,012	8,341	118
1911–12		10.80							263
1914–15	4.60	11.30	12,658	7,033	13,268	7,372	14,958	8,311	4
STOVE.									
1907–8		12.05							32
1908–9		13.20							51
1909–10		12.91							50
1910–11	3.66	12.78	12,595	6,998	13,073	7,263	14,989	8,328	62
1911–12		11.78							226
1914–15	3.81	12.05	12,585	6,992	13,084	7,269	14,877	8,266	19
CHESTNUT.									
1910–11	3.62	13.48	12,390	6,884	12,855	7,142	14,858	8,255	5
1911–12		12.66							220
1914–15	4.80	12.48	12,365	6,870	12,988	7,216	14,840	8,245	6
PEA.									
1906–7	4.81	16.04	11,886	6,604	12,487	6,938	14,873	8,263	19
1907–8		16.23							84
1908–9		15.62							135
1909–10		15.45							37
1910–11	4.20	17.42	11,720	6,512	12,234	6,797	14,815	8,231	89
1911–12	4.65	15.72	12,020	6,678	12,606	7,004	14,957	8,310	114
1912–13		15.91							17
1913–14		15.58							20
1914–15	3.85	15.25	12,150	6,751	12,637	7,021	14,911	8,285	119
BUCKWHEAT NO. 1.									
1906–7	5.09	18.05	11,491	6,384	12,107	6,727	14,774	8,208	15
1907–8		15.93							138
1908–9		17.81							118
1909–10		18.60							682
1910–11	4.60	18.80	11,415	6,342	11,965	6,648	14,735	8,187	53
1911–12	5.14	18.53	11,318	6,288	11,931	6,629	14,645	8,137	62
1912–13	5.06	20.40	11,088	6,133	11,626	6,459	14,606	8,115	13
1913–14	6.21	18.84	11,239	6,244	11,983	6,658	14,765	8,203	8
1914–15	4.66	18.54	11,449	6,361	12,009	6,672	14,742	8,191	49
BUCKWHEAT NO. 2.									
1907–8		17.13							6
1908–9		19.30							55
1909–10		18.60							61
1910–11	6.10	20.55	10,842	6,024	11,546	6,415	14,532	8,074	28
1911–12	7.55	18.20	10,953	6,085	11,847	6,582	14,483	8,047	13
1912–13	7.37	17.61	11,250	6,251	12,145	6,748	14,741	8,190	18
1913–14	7.58	19.31	10,962	6,090	11,861	6,590	14,699	8,167	17
1914–15	7.56	16.77	11,365	6,314	12,295	6,831	14,772	8,207	18
SCREENINGS.									
1910–11	6.07	12.62	12,244	6,803	13,035	7,242	14,918	8,288	31
1911–12	7.32	12.75	12,006	6,671	12,954	7,197	14,847	8,249	33
1912–13	6.42	13.84	11,997	6,666	12,820	7,123	14,879	8,267	19
1913–14	7.76	13.48	11,806	6,559	12,799	7,111	14,793	8,219	24
1914–15	6.98	13.61	11,923	6,624	12,818	7,122	14,837	8,243	24

TABLE 2.—*Coals analyzed for the United States*

FOREIGN COALS.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
AUSTRALIA.					
NEW SOUTH WALES.					
Newcastle	Aberdare		Aberdare	Run of mine	191
Do	Hebburn	Middle	Hebburn	Lump, over 1½-inch bar screen.	819
Do	Pelaw Main			Lump, over ¾-inch bar screen.	765
Do	do			do	1,084
Do	do			do	1,896
Do	do			do	621
Do	do			do	500
Do	do			Lump	115
Do	Pelaw Main and Alber Main.			Lump, over ¾-inch bar screen.	649
Do	do			do	2,901
Do	do			do	304
Do	do			do	294
Do	do			do	1,799
Do	Stanford-Richmond.			Lump, over ¾-inch screen.	4,206
Do	do			do	236
Do	do			do	200
Do	do			do	198
Do	do			do	400
Do	do			Lump, over 1½-inch bar screen.	1,989
Do	do			do	135
CANADA.					
BRITISH COLUMBIA.					
Michel and Fernie	Michel and Coal Creek.		Crows Nest Pass	Lump, over 2-inch screen.	2,210
Do	do		do	Lump	707
VANCOUVER ISLAND, BRITISH COLUMBIA.					
Cumberland	Comox		Comox	Run of mine	3,113
Do	do		do	Pea, through ¾-inch screen (washed).	3,252
Ladysmith	Dunsmuir-Wellington.		Dunsmuir-Wellington.	Lump, over ¾-inch screen.	200
Do	do		do	do	600
Do	do		do	do	2,369
Do	Extension		do	Lump, over 1½-inch bar screen.	911
Do	Dunsmuir-Wellington and Extension.		do	do	1,294
Nanaimo	Nanaimo			Lump	431
Do	do			Lump, over 3-inch bar screen.	2,157
Do	New Wellington			Lump	850
Do	do			do	235
Do	do			Lump, over ¾-inch bar screen.	1,100
Do	Wellington		Wellington	Lump, over 3½-inch screen.	2,100

Government during the fiscal years 1908–1915.

FOREIGN COALS.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.[a]
As received.	Dry coal.				As received.		Dry coal.		Moisture free and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B.t.u.	Calories.	B.t.u.	Calories.	B.t.u.	Calories.		
7	8	9	10	11	12	13	14	15	16	17	18	19
2.95	43.48	52.14	4.38	0.75	13,859	7,699	14,280	7,933	14,934	8,297	4	1
3.51	42.62	52.02	5.36	.79	13,630	7,572	14,126	7,848	14,926	8,292	18	2
2.80	41.65	52.99	5.36	.90	13,830	7,683	14,228	7,904	15,034	8,352	8	3
2.58	42.09	52.64	5.27	.87	13,937	7,743	14,306	7,948	15,102	8,390	13	4
2.69	42.54	52.30	5.16	.84	13,863	7,702	14,246	7,914	15,021	8,345	26	5
2.62	40.81	53.07	6.12	.88	13,708	7,616	14,077	7,821	14,995	8,331	11	6
2.76	44.36	51.40	4.24	.77	13,956	7,753	14,352	7,973	14,987	8,326	5	7
2.72	43.64	52.28	4.08	.88	13,958	7,754	14,348	7,971	14,958	8,310	5	8
2.83	43.22	50.70	6.08	.83	13,660	7,589	14,058	7,810	14,968	8,316	11	9
2.74	44.30	50.63	5.07	.74	13,872	7,707	14,263	7,924	15,025	8,347	22	10
2.60	43.83	52.04	4.13	.73	14,052	7,807	14,427	8,015	15,049	8,361	3	11
2.73	43.61	50.60	5.79	.76	13,687	7,604	14,071	7,817	14,936	8,298	5	12
2.79	43.89	50.81	5.30	.77	13,813	7,674	14,209	7,894	15,004	8,336	29	13
2.90	42.22	51.90	5.88	.84	13,704	7,613	14,113	7,841	14,995	8,331	32	14
2.57	41.73	51.98	6.29	.82	13,704	7,613	14,065	7,814	15,009	8,338	6	15
2.83	42.74	52.08	5.18	.84	13,825	7,681	14,238	7,904	15,005	8,336	4	16
2.80	42.30	52.48	5.22	.98	13,844	7,691	14,243	7,913	15,027	8,348	4	17
2.50	39.62	53.91	6.47	.88	13,833	7,685	14,188	7,882	15,169	8,427	4	18
2.36	41.44	51.52	7.04	.90	13,685	7,603	14,016	7,787	15,077	8,376	29	19
2.00	42.45	52.55	5.00	.75	14,149	7,861	14,438	8,021	15,198	8,443	3	20
1.73	24.38	61.10	14.52	.47	12,898	7,166	13,125	7,292	15,354	8,530	19	21
1.53	23.80	64.09	12.11	.48	13,331	7,406	13,538	7,521	15,403	8,557	6	22
2.91	32.91	51.27	15.82	1.43	12,208	6,782	12,574	6,986	14,937	8,298	45	23
7.23	34.53	47.71	17.76	.93	11,097	6,165	11,962	6,646	14,545	8,081	22	24
2.92	41.13	44.58	14.29	1.23	11,991	6,662	12,352	6,862	14,411	8,006	3	25
2.63	40.01	48.87	11.12	.90	12,623	7,013	12,964	7,202	14,586	8,103	5	26
2.92	39.55	46.67	13.78	1.12	12,175	6,764	12,541	6,967	14,545	8,081	15	27
2.10	39.56	51.16	9.28	.47	13,107	7,282	13,388	7,438	14,757	8,198	5	28
1.78	38.53	49.49	11.98	.45	12,788	7,104	13,020	7,233	14,792	8,218	6	29
2.13	40.52	46.28	13.20	1.58	12,386	6,881	12,656	7,031	14,581	8,101	7	30
3.09	40.45	47.30	12.25	1.09	12,388	6,882	12,783	7,101	14,568	8,093	21	31
2.96	40.76	45.10	14.14	.98	12,107	6,726	12,476	6,931	14,531	8,073	6	32
3.26	40.79	48.00	11.21	1.08	12,415	6,897	12,833	7,129	14,453	8,029	9	33
3.72	41.22	47.45	11.33	1.18	12,410	6,894	12,890	7,161	14,537	8,076	11	34
2.70	39.87	47.53	12.60	1.13	12,365	6,869	12,708	7,060	14,540	8,078	21	35

[a] See p. 52 to 101 of this bulletin for kind of coal, point of delivery, contract guaranties, and price.

TABLE 2.—*Coals analyzed for the United States*

FOREIGN COALS—Continued.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
CANADA—Contd.					
VANCOUVER ISLAND, BRITISH COLUMBIA—con.					
Nanaimo	Wellington		Wellington	Lump, over 3½-inch screen.	1,549
Do	do		do	do	600
Do	do		do	do	310
Do	do		do	Lump, over ¾-inch screen.	1,562
South Wellington	South Wellington			Lump	665
Do	do			do	1,007
Do	do			Lump, over 1-inch round-hole shaking screen.	838
Do	do			Lump, over 1-inch bar screen.	1,620

UNITED STATES COALS.

ALABAMA.					
BIBB COUNTY.					
Blockton	Blocton	Thompson	Blocton Cahaba	Lump	382
Do	do	do	do	do	81
Do	do	do	do	Lump, over 6-inch shaking screen.	384
Do	Blocton Nos. 2, 3, and 7.	do	do	Lump, over 2-inch screen.	590
Do	do	do	Old Tennessee Blocton Cahaba.	do	483
Garnsey	Garnsey	do	Garnsey	Washed steam	1,666
Marvel	Marvel Nos. 1 and 2.	Clark and Gholson.	Marvel Washed	Steam, over 2-inch screen.	2,067
Do	do	do	Marvel	Mixed sizes and washed.	1,586
JEFFERSON COUNTY.					
Blossburg	E	Pratt	Blossburg Pratt	Run of mine	1,242
Docena	Docena	do	Old Pratt	Lump, over 2-inch shaking screen.	261
Edgewater	Edgewater	do	do	Lump, over 2½-inch shaking screen.	3,011
Do	do	do	do	Screened steam	3,161
Ensley	Pratt No. 4	do	do	Lump, over 2½-inch screen.	401
Mineral Springs	Pratt	do		Lump	1,595
Do				Lump, over 2-inch bar screen.	1,337
Do				do	808
Palos	Palos Nos. 1 and 2.	Mary Lee	Pratt (Palos grade)	Run of mine	3,675
Do	do	do	do	do	850
Do	do	do	do	do	518
Pinson	Dixiana	Black Creek	Imperial	Pea (washed)	5,278
Pratt City	Pratt	Pratt	Old Tennessee Pratt.	Run of mine	1,616
Do	do	do	do	Lump, over 4-inch shaking screen.	1,306
Do	do	do	do	Lump, over 2-inch shaking screen.	841
Do	do	do	Pratt	Lump, over 1½ to 2½-inch round hole screen.	1,280
Do	do	do	do	do	148
Do	do	do	do	Lump	981

Government during the fiscal years 1908–1915—Continued.

FOREIGN COALS—Continued.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.
As received.	Dry coal.				As received.		Dry coal.		Moisture free and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B.t.u.	Calories.	B.t.u.	Calories.	B.t.u.	Calories.		
7	8	9	10	11	12	13	14	15	16	17	18	19
2.89	40.17	48.22	11.61	1.06	12,500	6,944	12,872	7,151	14,563	8,091	9	36
4.22	39.96	48.52	11.52	1.20	12,336	6,853	12,880	7,156	14,557	8,087	5	37
2.60	39.57	49.30	11.13	1.00	12,542	6,968	12,877	7,154	14,490	8,050	3	38
3.53	38.76	48.68	12.56	1.00	12,284	6,824	12,733	7,073	14,562	8,090	14	39
2.83	39.14	50.28	10.58	.69	12,754	7,086	13,125	7,292	14,678	8,154	8	40
2.64	40.14	45.70	14.16	1.72	12,225	6,792	12,556	6,976	14,627	8,126	12	41
2.40	39.96	47.34	12.70	1.70	12,557	6,976	12,866	7,148	14,738	8,188	5	42
2.46	40.44	49.75	9.81	.55	12,934	7,186	13,260	7,367	14,702	8,168	7	43

UNITED STATES COALS.

2.29	36.52	57.66	5.82	0.73	13,852	7,696	14,177	7,876	15,053	8,363	11	44
2.18	37.13	56.44	6.43	.70	13,722	7,623	14,028	7,793	14,992	8,329	3	45
2.24	37.93	56.29	5.78	.62	13,803	7,668	14,119	7,844	14,985	8,325	7	46
2.37	36.70	58.13	5.17	.53	13,925	7,736	14,263	7,924	15,041	8,356	3	47
2.18	37.55	56.58	5.87	.59	13,711	7,617	14,017	7,787	14,891	8,273	6	48
3.83	32.53	55.46	12.01	1.52	12,842	7,134	13,353	7,418	15,176	8,431	54	49
4.59	34.20	55.05	10.75	1.19	12,919	7,177	13,541	7,523	15,172	8,429	83	50
3.75	33.98	55.18	10.84	1.17	13,014	7,230	13,521	7,512	15,165	8,425	36	51
1.42	29.67	62.15	8.18	1.54	13,976	7,764	14,177	7,876	15,440	8,578	18	52
1.00	30.00	63.15	6.85	1.50	14,320	7,956	14,465	8,036	15,529	8,627	2	53
.99	29.82	64.12	6.06	1.68	14,481	8,045	14,626	8,126	15,570	8,650	16	54
1.50	29.50	63.21	7.29	1.50	14,160	7,867	14,376	7,987	15,506	8,614	28	55
1.05	31.70	62.15	6.15	1.98	14,377	7,987	14,580	8,072	15,462	8,601	2	56
1.45	28.81	59.90	11.29	1.65	13,419	7,455	13,616	7,564	15,449	8,527	12	57
1.33	30.96	59.68	9.36	2.13	13,843	7,691	14,030	7,794	15,479	8,599	25	58
1.55	31.39	59.94	8.67	1.95	13,886	7,714	14,105	7,836	15,444	8,580	14	59
3.44	28.95	61.39	9.66	.96	13,382	7,434	13,859	7,699	15,341	8,523	25	60
2.04	28.06	60.96	10.98	.78	13,375	7,431	13,654	7,586	15,338	8,521	5	61
1.53	28.87	61.70	9.43	1.08	13,665	7,592	13,877	7,709	15,322	8,512	3	62
2.83	31.90	61.39	6.71	.62	13,911	7,728	14,316	7,953	15,346	8,526	32	63
1.99	30.24	62.26	7.50	1.26	14,053	7,807	14,338	7,966	15,501	8,612	43	64
1.35	30.90	62.80	6.30	1.40	14,339	7,966	14,535	8,075	15,512	8,618	30	65
1.51	29.59	63.63	6.78	1.75	14,243	7,913	14,461	8,034	15,513	8,618	21	66
1.07	29.37	62.88	7.75	1.52	14,136	7,853	14,289	7,938	15,489	8,605	24	67
1.26	29.42	64.03	6.55	1.57	14,399	7,999	14,583	8,102	15,605	8,669	6	68
1.34	.....	.....	9.36	.....	13,916	7,731	14,105	7,836	15,562	8,646	14	69

TABLE 2.—*Coals analyzed for the United States*

UNITED STATES COALS—Continued.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
ALABAMA—Con.					
JEFFERSON COUNTY—con.					
Pratt City and Edgewater.	Pratt and Edgewater.	Pratt	Pratt	Lump, over 2-inch screen.	2,074
Pratt City and Ensley.	Various	do	do	Run of mine	494
Warrior		Black Creek	Sibleys Black Creek.	do	515
Warrior and El Vista.		do	Warrior Black Creek.	do	263
Watson	Eldorado	Pratt	Pratt	do	1,216
Do	do	do	do	do	765
Wylam	Pratt No. 5	do	Old Pratt	Lump, over 2-inch shaking screen.	556
Do	do	do	Pratt steam lump.	Lump, over 1¼ to 2½-inch shaking screen.	1,450
Do	do	do	do	Lump, over 2½-inch round-hole screen.	1,348
Do	Pratt No. 8	do	Old Pratt	Lump, over 2-inch shaking screen.	165
Do	Eldorado, Arcadia, Blossburg, and Banner.	Pratt and Mary Lee.	Pratt	Run of mine	1,316
SHELBY COUNTY.					
Acton	Acton	Helena	Acton	Through 3-inch screen (washed).	966
TUSCALOOSA COUNTY.					
Cottondale	Gilmore	Brookwood		Run of mine	2,271
Rock Castle	Rock Castle	Jagger	Jagger	do	1,243
WALKER COUNTY.					
Corona	Corona	Corona	Corona	Lump, over 2-inch shaking screen.	300
Sipsey	Sipsey	Black Creek	Sipsey	Lump, 3-inch and 5-inch (washed).	18,274
Townley	Townley	Jagger	Carbon Hill	Lump	372
ARKANSAS.					
FRANKLIN COUNTY.					
Denning	Denning	Denning	Denning	Lump, over 2-inch round-hole screen.	2,711
SEBASTIAN COUNTY.					
Hoffman and Huntington.	Hoffman, No. 7, and Huntington, No. 3.	Hart		Lump, over 2-inch round-hole screne.	2,877
Midland	Midland Valley		Bache-Denman	do	818
Do	do		do	do	982
Do	do		do	Run of mine	74
Do	do		do	do	217
Do	do		do	do	553

Government during the fiscal years 1908–1915—Continued.

UNITED STATES COALS—Continued.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.
As received.	Dry coal.				As received.		Dry coal.		Moisture free and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B.t.u.	Calories.	B.t.u.	Calories.	B.t.u.	Calories.		
7	8	9	10	11	12	13	14	15	16	17	18	19
2.18	29.78	64.31	5.91	1.41	14,299	7,944	14,618	8,121	15,536	8,631	14	70
1.39	30.73	63.45	5.82	1.19	14,366	7,981	14,569	8,094	15,469	8,594	9	71
3.03	30.73	63.15	6.12	.77	14,076	7,820	14,516	8,064	15,462	8,590	12	72
2.60	30.51	58.99	10.50	1.76	13,333	7,407	13,689	7,605	15,295	8,497	6	73
2.75	30.84	56.89	12.27	1.33	13,025	7,236	13,393	7,441	15,266	8,481	26	74
3.36	30.27	60.74	8.99	1.24	13,478	7,488	13,947	7,748	15,325	8,514	10	75
1.15	30.40	63.77	5.83	1.66	14,430	8,017	14,598	8,110	15,502	8,612	4	76
1.12	28.26	64.07	7.67	1.49	14,197	7,887	14,358	7,977	15,551	8,639	32	77
1.42	30.41	62.67	6.92	1.36	14,235	7,908	14,440	8,022	15,513	8,618	18	78
1.30	33.40	60.00	6.60	1.78	14,203	7,891	14,390	7,994	15,407	8,559	2	79
2.94	30.10	58.60	11.30	1.31	13,222	7,346	13,622	7,568	15,357	8,532	20	80
4.40	35.53	56.87	7.60	.47	13,288	7,382	13,900	7,722	15,043	8,357	3	81
6.96	35.04	52.72	12.24	1.01	12,161	6,756	13,071	7,262	14,894	8,274	11	82
1.81	28.24	61.86	9.90	.89	13,660	7,589	13,912	7,729	15,441	8,578	16	83
2.73	30.27	52.23	8.50	1.43	13,197	7,332	13,567	7,537	14,827	8,237	3	84
3.16	35.87	58.68	5.45	1.07	13,723	7,624	14,171	7,873	14,988	8,327	19	85
4.50	33.78	53.55	12.67	.95	12,146	6,748	12,718	7,066	14,563	8,091	8	86
1.54	14.74	75.00	10.26	2.55	13,644	7,580	13,857	7,698	15,441	8,578	23	87
1.53	19.37	71.08	9.55	1.60	13,702	7,612	13,915	7,731	15,384	8,547	23	88
3.40	17.80	72.37	9.83	1.38	13,487	7,493	13,962	7,757	15,484	8,602	20	89
2.09	18.32	70.52	11.16	1.85	13,408	7,449	13,694	7,608	15,414	8,563	11	90
3.30	16.64	68.21	15.15	.81	12,639	7,022	13,070	7,261	15,404	8,558	2	91
2.33	17.25	69.45	13.30	1.86	13,039	7,244	13,350	7,417	15,398	8,554	5	92
2.15	15.05	68.90	16.05	2.88	12,557	6,976	12,833	7,129	15,286	8,492	6	93

TABLE 2.—*Coals analyzed for the United States*

UNITED STATES COALS—Continued.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
ARKANSAS AND OKLAHOMA.					
SEBASTIAN AND LE FLORE COUNTIES.					
Hackett, Huntington, and Witteville.	Hackett, Huntington, and Witteville.	.....	Hackett-Huntington.	Lump, over 2-inch shaking screen.	2,283
COLORADO.					
GUNNISON COUNTY.					
Crested Butte.....	Floresta.....	Ruby.....	Ruby.....	Anthracite, through ½-inch, over ⅜-inch screen.	298
Do.....	Horace.....	.....	.....	Anthracite, No. 6..	360
Do.....	.....do.....	.....	.....	.....do.....	350
Do.....	.....do.....	.....	.....	.....do.....	448
Do.....	.....do.....	.....	.....	.....do.....	325
LAS ANIMAS COUNTY.					
Aguilar.....	Royal.....	.....	Royal.....	Lump, over 1¼-inch screen.	761
Do.....	.....do.....	.....	.....do.....	Lump, over 1½-inch bar screen.	3,336
Beacon.....	Beacon.....	.....	Green Canon.....	Lump, over 1½-inch round-hole shaking screen.	16,929
Do.....	.....do.....	.....	.....do.....	.....do.....	2,491
Do.....	.....do.....	.....	.....do.....	.....do.....	2,000
Do.....	.....do.....	.....	.....do.....	.....do.....	3,460
Do.....	Green Canon.....	.....	.....do.....	Run of mine.....	1,280
Primero.....	North and East Primero.	Primero.....	Primero.....	Lump, over 1½-inch bar screen.	749
Do.....	First West Primero.	.....do.....	.....do.....	Lump, over 2½-inch bar screen.	259
Do.....	First West and North and East Primero.	.....do.....	.....do.....	Mixture of lump over 1¼-inch and 2½-inch screens.	1,008
Do.....	.....do.....	.....do.....	.....do.....	.....do.....	900
Rugby.....	Primrose.....	.....	Primrose.....	Lump, over 1½-inch round-hole shaking screen.	9,304
Do.....	.....do.....	.....	.....do.....	.....do.....	4,324
Do.....	.....do.....	.....	.....do.....	.....do.....	2,737
MESA COUNTY.					
Grand Junction...	Book Cliff.....	Cameo.....	Book Cliff.....	Run of mine.....	319
ROUTT COUNTY.					
Oak Creek.....	Pinnacle.....	Mammoth.....	Pinnacle.....	Run of mine.....	1,441
Do.....	.....do.....	.....do.....	.....do.....	.....do.....	799
Do.....	Yampa Valley....	McKinley.....	Yampa Valley....	.....do.....	700
Do.....	.....do.....	.....do.....	.....do.....	.....do.....	1,212
Do.....	.....do.....	.....do.....	.....do.....	.....do.....	326
WELD COUNTY.					
Firestone.....	Russell.....	Emerson.....	Russell.....	Run of mine.....	129

Government during the fiscal years 1908–1915—Continued.

UNITED STATES COALS—Continued.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.
As received.	Dry coal.				As received.		Dry coal.		Moisture free and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B.t.u.	Calories.	B.t.u.	Calories.	B.t.u.	Calories.		
7	8	9	10	11	12	13	14	15	16	17	18	19
1.52	24.62	60.30	15.08	3.65	12,863	7,146	13,062	7,257	15,382	8,546	15	94
3.62	4.85	78.57	16.58	.81	11,826	6,570	12,270	6,817	14,709	8,172	15	95
1.76	7.42	82.33	10.25	1.08	13,508	7,504	13,750	7,639	15,320	8,511	12	96
2.26	7.72	82.24	10.04	.93	13,470	7,483	13,781	7,656	15,319	8,511	7	97
2.57	8.93	79.44	11.63	1.16	13,189	7,327	13,537	7,521	15,319	8,511	10	98
2.37	8.03	81.20	10.17	.93	13,408	7,449	13,733	7,629	15,288	8,493	3	99
2.07	36.02	50.24	13.74	.60	12,672	7,040	12.940	7,189	15,001	8,334	10	100
1.78	33.21	50.28	16.51	.59	12,298	6,832	12,521	6,956	14,997	8,332	17	101
2.53	36.90	52.00	11.10	.74	12,856	7,142	13,190	7,328	14,837	8,243	75	102
2.37	37.60	55.55	6.85	.65	13,572	7,540	13,901	7,723	14,923	8,291	45	103
2.50	37.74	52.99	9.27	.63	13,148	7,304	13,485	7,492	14,863	8,257	22	104
2.66	37.65	50.77	11.58	.68	12,770	7,094	13,119	7,288	14,837	8,243	25	105
3.87	36.91	49.91	13.18	.75	12,320	6,844	12,816	7,120	14,762	8,201	11	106
1.47	30.91	56.03	13.06	.53	13,081	7,267	13,276	7,376	15,270	8,483	12	107
1.27	29.80	53.03	17.17	.59	12,462	6,923	12,622	7,012	15,238	8,466	6	108
1.40	30.54	55.03	14.43	.55	12,875	7,153	13,058	7,254	15,260	8,478	18	109
1.60	29.72	55.37	14.91	.61	12,738	7,077	12,945	7,192	15,213	8,452	6	110
2.91	36.65	53.48	9.87	.48	12,858	7,143	13,243	7,357	14,693	8,163	62	111
2.90	37.06	52.42	10.52	.48	12,713	7,063	13,093	7,274	14,632	8,129	38	112
3.22	38.51	51.72	9.77	.46	12,730	7,072	13,154	7,308	14,578	8,099	15	113
7.50	36.38	53.42	10.20	.57	11,785	6,547	12,741	7,078	14,188	7,882	2	114
8.12	40.07	54.39	5.54	.71	12,195	6,775	13,273	7,374	14,051	7,806	41	115
8.07	41.31	52.15	6.54	.73	12,061	6,701	13,120	7,289	14,038	7,799	19	116
8.45	41.08	52.84	6.08	.68	12,125	6,736	13,244	7,358	14,101	7,834	9	117
8.15	41.95	52.14	5.91	.73	12,128	6,738	13,204	7,336	14,033	7,796	10	118
7.96	40.83	52.01	7.16	.89	12,030	6,683	13,070	7,261	14,078	7,821	7	119
23.55	40.45	53.30	6.25	.55	9,445	5,247	12,355	6,864	13,179	7,322	2	120

TABLE 2.—*Coals analyzed for the United States*

UNITED STATES COALS—Continued.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
GEORGIA.					
WALKER COUNTY.					
Pittsburg	Durham	Durham	Durham	Run of mine	2,335
Do	do	do	do	do	2,095
ILLINOIS.					
BOND COUNTY.					
Pocahontas	No. 1	No. 6		Lump	1,028
CHRISTIAN COUNTY.					
Pana	Pana	No. 6		Nos. 1 and 2 washed nut.	564
Do	do	do		do	6,065
CLINTON COUNTY.					
Breeze	Breeze	No. 6	Breeze	Lump, over 2-inch screen.	2,694
Do	do	do	do	do	1,263
FRANKLIN COUNTY.					
Christopher	No. 1	No. 6	Purity	Lump, over 3-inch screen.	240
Do	North	do	Brighton	do	171
Do	do	do	do	do	68
Do	do	do	do	Run of mine	120
Do	do	do	do	do	1,144
Do	North and Christopher, No. 1.	do		Lump, over 3-inch screen.	184
MACOUPIN COUNTY.					
Mount Olive	Mount Olive, No. 8	No. 6	Mount Olive	Lump, over 3-inch screen.	7,793
Staunton	Staunton, No. 2	do	Staunton	Through 2-inch screen, over 1¼-inch screen.	395
Do	do	do	do	do	3,205
Do	do	do	do	Lump	3,284
Do	Staunton, No. 7	do	do	do	3,468
Do	Staunton, No. 14	do	do	Lump, over 2-inch screen.	7,338
Do	Staunton	do	do	Lump, over 3-inch screen.	6,351
MADISON COUNTY.					
Collinsville	Cantine	No. 6	Cantine	Lump, over 1¼-inch screen.	2,656
Do	do	do	do	Lump, over 6-inch screen.	72
Do	do	do	do	Lump	200
PEORIA COUNTY.					
Bartlett	Empire, No. 2	No. 5	Empire	Lump	641
Do	do	do	do	Run of mine	4,118

Government during the fiscal years 1908–1915—Continued.

UNITED STATES COALS—Continued.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.
As received.	Dry coal.				As received.		Dry coal.		Moisture free and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B.t.u.	Calories.	B.t.u.	Calories.	B.t.u.	Calories.		
7	8	9	10	11	12	13	14	15	16	17	18	19
2.76	20.33	73.89	5.78	1.06	14,364	7,980	14,772	8,207	15,678	8,710	35	121
1.21	21.50	71.73	6.77	.83	14,393	7,996	14,569	8,094	15,627	8,682	9	122
10.69	39.16	47.65	13.19	4.24	10,951	6,084	12,262	6,812	14,125	7,847	17	123
6.76	36.82	51.33	11.85	2.54	11,907	6,615	12,770	7,094	14,487	8,048	20	124
7.08	37.60	52.30	10.10	2.36	12,150	6,750	13,076	7,264	14,545	8,081	114	125
10.90	41.14	45.50	13.36	4.22	10,916	6,064	12,251	6,806	14,140	7,856	25	126
9.66	40.49	44.67	14.84	4.57	10,867	6,037	12,029	6,683	14,125	7,847	15	127
7.83	36.29	53.58	10.13	1.12	12,049	6,694	13,073	7,263	14,547	8,082	10	128
7.73	35.75	55.05	9.20	.82	12,081	6,712	13,093	7,274	14,420	8,011	10	129
8.58	35.54	54.53	9.93	.57	11,903	6,613	13,020	7,233	14,455	8,031	4	130
7.90	36.08	53.45	10.47	.80	11,879	6,599	12,898	7,166	14,406	8,003	4	131
8.59	37.29	52.27	10.44	.84	11,811	6,562	12,921	7,178	14,427	8,015	14	132
8.72	39.28	51.66	9.06	.67	11,965	6,647	13,108	7,282	14,414	8,008	5	133
11.97	43.23	44.93	11.84	4.64	10,925	6,069	12,410	6,894	14,077	7,821	52	134
10.80	40.30	46.95	12.75	3.82	10,889	6,049	12,207	6,782	13,991	7,773	22	135
10.60	40.22	45.93	13.85	4.48	10,842	6,023	12,127	6,737	14,077	7,821	64	136
10.89	41.44	44.67	13.89	4.38	10,828	6,016	12,151	6,751	14,111	7,839	28	137
11.29	40.53	46.68	12.79	4.28	10,903	6,057	12,291	6,828	14,094	7,830	23	138
11.87	40.93	46.42	12.65	4.55	10,872	6,040	12,336	6,853	14,122	7,846	55	139
11.89	43.84	44.78	11.38	4.54	10,971	6,095	12,452	6,918	14,051	7,806	20	140
10.90	42.56	43.59	13.85	4.56	10,890	6,050	12,222	6,790	14,187	7,882	31	141
8.90	41.82	44.29	13.89	4.31	11,082	6,157	12,165	6,758	14,127	7,848	7	142
10.54	43.47	45.44	11.09	4.59	11,265	6,258	12,592	6,996	14,163	7,868	5	143
12.41	37.70	45.16	17.14	3.08	10,426	5,792	11,903	6,613	14,365	7,981	10	144
13.70	39.64	44.80	15.56	3.09	10,517	5,843	12,187	6,771	14 433	8,018	38	145

TABLE 2.—*Coals analyzed for the United States*

UNITED STATES COALS—Continued.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
ILLINOIS—Contd.					
PERRY COUNTY.					
Duquoin	Majestic	No. 6	Majestic	Through 3-inch screen, over 1½-inch screen.	2,355
Do	do	do	do	Lump, over 1½-inch screen.	5,357
Do	do	do	do	Lump, over 2-inch screen.	9,630
Do	do	do	do	Screened lump	5,123
Do	do	do	do	Through 3-inch screen.	11,739
Do	Paradise	do	Paradise	Run of mine	1,362
Do	do	do	do	Screenings	2,026
Do	Queen	do	Queen	Run of mine	26,634
Do	Security	do	Security	do	7,533
ST. CLAIR COUNTY.					
Belleville	Prairie	No. 6	Prairie	Lump	423
Do	do	do	do	do	3,676
Do	do	do	do	do	1,255
Do	do	do	do	do	2,906
East St. Louis	O'Fallon	do	O'Fallon	do	2,844
Do	do	do	do	do	1,087
SALINE COUNTY.					
Eldorado	Eldorado	No. 5	Eldorado	Lump, over 6-inch screen.	528
Do	do	do	do	Lump, over 1½-inch round-hole screen.	675
Do	do	do	do	do	394
Harrisburg	Big Creek, No. 2	do		Through 3-inch screen; over 1½-inch screen.	5,622
Do	do	do		do	390
Do	Big Creek	do	Premium	do	2,203
Do		do		Nos. 1 and 2 nut	6,504
Do		do		do	505
Harrisburg and Eldorado.		do		do	4,589
Near Harrisburg	O'Gara, No. 1 to No. 15.	do	Harrisburg	Run of mine	2,719
Ledford	No. 2	do	Premium white ash.	Lump, over 3-inch screen.	568
Do		do	do	Lump	387
SANGAMON COUNTY.					
Springfield	Peerless	No. 5		Run of mine	5,733
VERMILLION COUNTY.					
Danville	Electric	No. 7	Electric	Through 3½-inch screen.	14,422
Do	do	do	do	do	18,958
Do	do	do	do	do	18,060
Do	do	do	do	do	15,332
Do	do	do	do	No. 1 lump	140
Do	Mission Field, Nos. 1, 2, and 3.	do		Lump and slack	16,845

Government during the fiscal years 1908–1915—Continued.

UNITED STATES COALS—Continued.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.
As received.	Dry coal.				As received.		Dry coal.		Moisture free and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B.t.u.	Calories.	B.t.u.	Calories.	B.t.u.	Calories.		
7	8	9	10	11	12	13	14	15	16	17	18	19
8.40	36.37	50.57	13.06	0.86	11,387	6,326	12,431	6,906	14,298	7,943	13	146
9.15	38.42	53.50	8.08	.92	12,006	6,670	13,215	7,342	14,377	7,987	23	147
9.16	38.03	50.11	11.86	1.14	11,463	6,368	12,619	7,011	14,317	7,954	59	148
9.18	38.38	52.31	9.31	1.31	11,805	6,558	12,998	7,221	14,332	7,962	21	149
9.28	37.39	51.57	11.04	1.09	11,532	6,407	12,712	7,062	14,290	7,939	41	150
10.63	35.48	49.82	14.70	1.05	10,903	6,057	12,200	6,778	14,302	7,946	6	151
10.39	36.83	48.29	14.88	1.15	10,828	6,016	12,083	6,713	14,195	7,886	10	152
9.11	37.92	50.99	11.09	.98	11,546	6,414	12,703	7,057	14,287	7,937	56	153
10.24	37.87	51.04	11.09	1.57	11,400	6,333	12,700	7,056	14,284	7,936	37	154
9.22	40.91	44.81	14.28	4.12	11,034	6,130	12,155	6,753	14,180	7,878	21	155
9.34	40.70	43.88	15.42	4.64	10,921	6,067	12,046	6,692	14,242	7,912	56	156
9.46	42.64	42.03	15.33	4.99	10,890	6,050	12,028	6,682	14,206	7,892	12	157
9.46	43.68	42.46	13.86	4.48	11,077	6,154	12,234	6,797	14,202	7,890	25	158
9.34	43.30	43.15	13.55	4.41	11,138	6,188	12,286	6,826	14,212	7,896	26	159
8.14	42.53	42.50	14.97	5.18	11,074	6,152	12,055	6,697	14,177	7,876	13	160
7.12	36.50	53.83	9.67	2.31	12,257	6,809	13,197	7,332	14,610	8,117	12	161
6.72	36.96	53.84	9.20	2.21	12,382	6,879	13,274	7,374	14,619	8,122	5	162
6.58	38.04	53.92	8.04	1.98	12,584	6,991	13,470	7,483	14,648	8,138	5	163
6.71	37.11	54.36	8.53	2.32	12,514	6,952	13,414	7,452	14,665	8,147	83	164
5.86	35.75	52.85	11.40	2.75	12,212	6,784	12,972	7,207	14,641	8,134	24	165
5.38	37.91	50.39	11.70	3.82	12,148	6,749	12,839	7,133	14,540	8,078	13	166
5.59	36.15	54.08	9.77	2.51	12,467	6,926	13,205	7,336	14,635	8,131	61	167
5.18	35.81	52.04	12.15	3.15	12,144	6,747	12,807	7,115	14,578	8,099	22	168
6.74	39.29	49.60	11.11	2.90	12,056	6,698	12,927	7,182	14,543	8,079	39	169
6.83	37.20	53.49	9.31	2.26	12,380	6,878	13,288	7,382	14,652	8,140	59	170
6.45	37.84	53.12	9.04	2.59	12,454	6,919	13,313	7,396	14,636	8,132	11	171
5.57	38.60	53.37	8.03	2.01	12,811	7,117	13,567	7,537	14,752	8,196	10	172
13.86	.....	.....	13.79	.....	10,517	5,843	12,209	6,783	14,162	7,868	157	173
12.47	39.14	44.67	16.19	3.33	10,535	5,853	12,036	6,687	14,361	7,978	106	174
12.17	39.61	42.53	17.86	3.77	10,374	5,763	11,812	6,562	14,380	7,989	126	175
12.63	40.53	43.93	15.54	2.96	10,576	5,876	12,105	6,725	14,332	7,962	72	176
12.56	41.77	43.60	14.63	3.00	10,721	5,956	12,261	6,812	14,362	7,979	32	177
11.65	40.20	49.45	10.35	2.58	11,450	6,361	12,960	7,200	14,456	8,031	4	178
11.61	41.62	44.41	13.97	2.94	10,962	6,090	12,402	6,890	14,416	8,009	37	179

TABLE 2.—*Coals analyzed for the United States*

UNITED STATES COALS—Continued.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
ILLINOIS—Contd.					
WILLIAMSON COUNTY.					
Carterville	Burr C	No. 6	Carterville	Lump, over 6-inch screen.	1,428
Do	do	do	Burr	Lump, over 3-inch shaking screen.	2,050
Do	do	do	do	Slack, through 2-inch shaking screen.	1,056
Johnston City	Black Brier	do	Black Brier	Slack, over 1¼-inch round-hole screen.	2,294
Do	do	do	do	do	9,439
Do	do	do	do	do	1,047
Do	do	do	do	do	991
Do	do	do	do	do	2,254
Do	do	do	do	Through 3-inch screen, over 1¼-inch screen.	1,294
Do	do	do	do	Run of mine	224
Marion	Scranton Big Muddy.	do		Lump	64
INDIANA.					
GREEN COUNTY.					
Jasonville and Midland.	Lattas Creek and Gilmore.	No. 4		Lump, over 1¼-inch screen.	652
VIGO COUNTY.					
			Vigo	Nos. 1 and 2 nut	5,753
WARWICK COUNTY.					
Booneville	John Bull	No. 5		Run of mine	199
IOWA.					
MONROE COUNTY.					
Avery	Smoky Hollow			Run of mine	1,476
KANSAS.					
CHEROKEE COUNTY.					
Mineral			Cherokee	Lump, over 2-inch round-hole screen.	5,076
Do			do	do	632
Do			do	Lump, over 1¼-inch round-hole screen.	8,753
Do			do	Run of mine	660
Weir			do	do	998
CRAWFORD COUNTY.					
Englevale		Cherokee	Cherokee	Run of mine	1,605
Do		do	do	do	1,645
Mulberry	Cherokee, No. 3		do	do	1,443

Government during the fiscal years 1908–1915—Continued.

UNITED STATES COALS—Continued.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.
As received.	Dry coal.				As received.		Dry coal.		Moisture free and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B.t.u.	Calories.	B.t.u.	Calories.	B.t.u.	Calories.		
7	8	9	10	11	12	13	14	15	16	17	18	19
7.11	32.05	55.62	12.33	1.35	11,803	6,557	12,706	7,059	14,493	8,052	10	180
7.88	34.94	55.98	9.08	1.04	12,216	6,787	13,261	7,367	14,585	8,103	8	181
7.38	34.60	56.28	9.12	1.09	12,224	6,791	13,198	7,332	14,522	8,068	4	182
7.93	34.54	55.31	10.15	1.31	12,033	6,685	13,069	7,261	14,545	8,081	12	183
7.43	35.66	54.27	10.07	1.29	12,079	6,711	13,049	7,249	14,510	8,061	92	184
7.33	35.09	56.02	8.89	1.57	12,280	6,822	13,251	7,362	14,544	8,080	12	185
8.07	34.42	53.17	12.41	1.28	11,671	6,484	12,695	7,053	14,494	8,052	8	186
7.79	36.48	54.89	8.63	1.17	12,243	6,802	13,277	7,376	14,531	8,073	10	187
6.90	35.80	53.70	10.50	1.43	12,092	6,718	12,988	7,216	14,512	8,062	8	188
7.98	33.80	55.42	10.78	1.55	11,895	6,608	12,926	7,181	14,488	8,049	5	189
7.76	37.29	50.47	12.24	3.06	11,671	6,484	12,653	7,029	14,418	8,010	6	190
13.13	40.90	50.02	9.08	1.69	11,536	6,409	13,280	7,378	14,606	8,114	9	191
10.85	40.54	50.91	8.55	1.18	11,808	6,560	13,245	7,358	14,483	8,046	52	192
10.75	43.15	44.10	12.75	4.21	11,181	6,212	12,528	6,960	14,359	7,977	4	193
13.24	40.45	38.68	20.87	5.23	9,775	5,431	11,267	6,259	14,239	7,911	13	194
3.05	33.79	51.71	14.50	5.26	12,436	6,877	12,827	7,126	15,002	8,334	13	195
3.37	36.53	51.40	12.07	4.99	12,717	7,065	13,160	7,311	14,966	8,314	4	196
4.21	32.49	54.28	13.23	3.86	12,503	6,946	13,053	7,252	15,043	8,357	82	197
4.41	30.33	51.24	18.43	4.24	11,694	6,497	12,233	6,796	14,997	8,332	3	198
4.60	34.83	52.80	12.37	6.04	12,443	6,913	13,043	7,246	14,884	8,269	12	199
4.74	32.15	50.50	17.35	5.64	11,666	6,481	12,246	6,803	14,817	8,232	19	200
8.30	36.02	48.48	15.50	4.10	11,211	6,228	12,226	6,792	14,469	8,038	27	201
8.17	35.63	48.45	15.92	4.55	11,190	6,217	12,186	6,770	14,493	8,052	46	202

TABLE 2.—*Coals analyzed for the United States*

UNITED STATES COALS—Continued.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
KANSAS—Contd.					
LEAVENWORTH COUNTY.					
Leavenworth	Home-Riverside	Leavenworth	Leavenworth	Lump, over 2-inch round-hole screen.	13,731
Do	do	do	do	do	10,482
Do	do	do	do	do	10,132
Do	do	do	Home-Riverside	Lump	7,009
Do	Home-Riverside, Nos. 1 and 2.	do	do	Run of mine	9,449
Richardson	Carr	do	Richardson	Lump, over 5-inch screen.	9,262
Do	do	do	do	Lump, over 2-inch round-hole screen.	7,695
Do	do	do	do	Run of mine	8,135
Do	do	do	do	do	8,752
KENTUCKY.					
BELL COUNTY.					
Blanche	Blanche	Straight Creek	Straight Creek	Lump	156
Do	do	do	do	Run of mine	793
Pineville	Moss Creek		Straight Creek, Jellico.	Lump	137
Rim	Black Raven	Straight Creek		Run of mine	844
Straight Creek	Barker	do	Straight Creek	Through 2½-inch screen.	1,559
HOPKINS COUNTY.					
St. Charles	St. Charles	No. 9		Run of mine	1,416
MUHLENBURG COUNTY.					
Drakesboro	Diamond Block	No. 9		Run of mine	274
UNION COUNTY.					
Sturgis	Nos. 1, 2, and 8	No. 9	Tradewater	Run of mine	4,534
Do	Nos. 1, 2, 8, and 9	do	do	do	5,994
WEBSTER COUNTY.					
Clay	No. 7	No. 12	Caney Creek	Run of mine	401
WHITLEY COUNTY.					
Burk Hollow	Burk Hollow	Blue Gem	Burk Hollow	Run of mine	552
Mountain Ash	Mountain Ash	Jellico	Mountain Ash	Lump	877
MARYLAND.					
ALLEGANY COUNTY.					
Eckhart	Washington, No. 2.	Upper Sewickley or Tyson.		Run of mine	499
Do	do	do		do	95
Do	do	do		do	18,315
Frostburg (near)	Consolidation mines.	Pittsburgh or Big Vein.	Georges Creek	do	2,090
Do	do	do	do	do	2,531
Do	do	do	do	do	475
Do	do	do	do	do	3,609
Do	do	do	do	do	2,195

Government during the fiscal years 1908–1915—Continued.

UNITED STATES COALS—Continued.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.
As received.	Dry coal.				As received.		Dry coal.		Moisture free and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B.t.u.	Calories.	B.t.u.	Calories.	B.t.u.	Calories.		
7	8	9	10	11	12	13	14	15	16	17	18	19
9.67	40.31	43.40	16.29	5.30	10,869	6,038	12,033	6,685	14,375	7,986	68	203
10.00	39.65	45.61	14.74	4.75	11,107	6,171	12,341	6,856	14,474	8,041	43	204
9.57	38.76	44.30	16.94	5.36	10,840	6,022	11,987	6,659	14,432	8,018	71	205
10.24	41.43	44.89	13.68	4.77	11,208	6,227	12,487	6,938	14,466	8,037	39	206
7.44	41.19	44.20	14.61	5.00	11,415	6,342	12,333	6,852	14,443	8,024	14	207
8.55	39.84	44.31	15.85	5.40	11,149	6,194	12,191	6,773	14,487	8,048	23	208
9.42	40.75	44.21	15.04	5.01	11,121	6,178	12,277	6,821	14,450	8,028	40	209
8.79	39.01	43.25	17.74	5.09	10,888	6,049	11,937	6,632	14,511	8,062	42	210
8.07	39.54	42.96	17.50	5.19	10,966	6,092	11,929	6,627	14,459	8,033	25	211
2.35	37.93	58.09	3.98	1.08	14,198	7,888	14,540	8,078	15,143	8,413	6	212
2.30	36.89	52.88	10.23	.79	13,211	7,339	13,522	7,512	15,063	8,368	4	213
2.40	40.18	56.80	3.02	.87	14,271	7,929	14,622	8,123	15,077	8,376	4	214
5.06	36.11	55.01	8.88	1.01	12,971	7,207	13,662	7,590	14,993	8,329	14	215
3.45	33.83	54.77	11.40	1.57	12,796	7,109	13,253	7,363	14,958	8,310	28	216
7.97	.....	.....	13.82	.....	11,458	6,366	12,450	6,917	14,447	8,026	17	217
9.75	43.28	44.20	12.52	3.79	11,370	6,317	12,598	6,999	14,401	8,001	4	218
3.70	38.36	51.08	10.56	2.80	12,744	7,080	13,234	7,352	14,797	8,221	5	219
3.75	38.42	51.21	10.37	2.81	12,787	7,104	13,285	7,381	14,822	8,234	6	220
4.65	36.50	52.65	10.85	1.58	12,553	6,974	13,165	7,314	14,767	8,204	2	221
3.97	36.70	56.13	7.17	.78	13,348	7,416	13,900	7,722	14,974	8,319	3	222
2.80	39.08	55.72	5.20	.98	13,888	7,716	14,288	7,938	15,072	8,373	4	223
2.18	20.32	72.91	6.77	1.08	14,259	7,922	14,577	8,098	15,636	8,687	5	224
2.08	19.73	72.60	7.67	1.09	14,106	7,837	14,406	8,003	15,603	8,668	12	225
1.99	20.06	71.83	8.11	1.27	14,036	7,798	14,321	7,956	15,585	8,658	81	226
2.21	18.83	72.36	8.81	.97	13,935	7,742	14,250	7,917	15,627	8,682	14	227
3.09	18.65	72.47	8.88	.98	13,766	7,648	14,205	7,892	15,589	8,661	19	228
1.77	19.33	71.89	8.78	.96	13,960	7,756	14,212	7,896	15,580	8,656	6	229
1.45	18.63	72.28	9.09	.96	13,951	7,751	14,156	7,864	15,571	8,651	13	230
3.00	19.68	72.20	8.12	.91	13,902	7,723	14,332	7,962	15,599	8,666	12	231

TABLE 2.—*Coals analyzed for the United States*

UNITED STATES COALS—Continued.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
MARYLAND—Con.					
ALLEGANY CO.—continued.					
Frostburg (near)	Consolidation mines.	Pittsburgh or Big Vein.	Georges Creek	Run of mine	4,576
Do	do	do	do	do	216
Do	do	do	do	do	491
Do	do	do	do	do	6,840
Do	do	do	do	do	5,938
Do	do	do	do	do	4,814
Do	do	do	do	do	2,112
Do	do	do	do	do	685
Do	do	do	do	do	446
Do	do	do	do	do	
Lonaconing	Nos. 1, 2, 3, and 4	Upper Sewickley or Tyson.		do	12,457
Do	do	do		do	1,367
Do	do	do		do	20,406
Do	do	do		do	11,911
Do	do	do		do	1,256
Ocean	Ocean	Pittsburgh or Big Vein.	Georges Creek	do	2,317
Do	do	do	do	do	123
Do	do	do	do	do	335
Do	do	do	do	do	332
Do	do	do	do	do	331
Do	do	do	do	do	431
Vale Summit	Mertens	B or Lower Kittanning.	Davis Six-Foot	do	225
GARRETT COUNTY.					
Dodson	Dodson	B or Lower Kittanning.	Dodson-Cumberland.	Run of mine	216
MICHIGAN.					
SAGINAW COUNTY.					
Saginaw	Riverside	Saginaw	Riverside	Lump, over ¾-inch screen.	1,750
MISSOURI.					
MACON COUNTY.					
Bevier	Nos. 8 and 9	Bevier	Bevier	Run of mine	813
MONTANA.					
CARBON COUNTY.					
Bear Creek	Bear Creek	Nos. 2 and 3	Original Bear Creek.	Slack	130
Do	do	do	do	Lump	1,815
Do	do	do	do	do	1,650
Do	do	do	do	do	1,041
Do	do	do	do	do	2,021
Do	do	do	do	do	1,955
Do	do	do	do	Lump, over 2-inch round-hole shaking screen.	1,496
Do	do	do	do	do	550
Do	do	do	Bear Creek	do	1,106
Do	International	No. 3	Peerless Bear Creek.	Slack forkings	209
Washoe	Nos. 2 and 3	No. 2	Faultless	Lump, over 2-inch screen.	2,940

Government during the fiscal years 1908–1915—Continued.

UNITED STATES COALS—Continued.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.
As received.	Dry coal.				As received.		Dry coal.		Moisture free and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B.t.u.	Calories.	B.t.u.	Calories.	B.t.u.	Calories.		
7	8	9	10	11	12	13	14	15	16	17	18	19
1.47	18.93	72.34	8.73	.97	14,024	7,791	14,233	7,907	15,594	8,663	11	232
1.79	19.75	72.04	8.21	.94	14,099	7,833	14,356	7,976	15,640	8,689	7	233
1.65	19.21	72.04	8.75	.94	14,027	7,793	14,262	7,923	15,630	8,683	8	234
2.63	19.19	72.87	7.94	1.02	13,966	7,759	14,343	7,968	15,580	8,656	36	235
1.78	18.84	72.74	8.42	.94	14,023	7,791	14,277	7,932	15,590	8,661	23	236
1.54	18.29	72.87	8.84	.93	13,984	7,769	14,203	7,891	15,580	8,656	14	237
3.50	18.46	73.61	7.93	.99	13,830	7,683	14,332	7,962	15,566	8,648	11	238
2.08	18.44	72.38	9.18	.90	13,838	7,688	14,132	7,851	15,560	8,644	5	239
2.46	19.20	73.42	7.38	.92	14,110	7,839	14,466	8,037	15,619	8,677	5	240
2.47	19.06	72.85	8.09	.89	13,996	7,776	14,350	7,972	15,613	8,674	21	241
2.21	20.86	70.26	8.88	1.23	13,881	7,712	14,195	7,886	15,578	8,654	51	242
1.49	20.64	70.17	9.19	1.31	13,969	7,760	14,180	7,878	15,615	8,675	5	243
1.99	20.42	70.86	8.72	1.36	13,931	7,739	14,214	7,897	15,572	8,651	89	244
2.61	20.41	70.90	8.69	1.22	13,794	7,663	14,164	7,869	15,512	8,618	50	245
2.30	20.10	70.77	9.13	1.31	13,785	7,658	14,110	7,839	15,528	8,627	21	246
2.39	.....	.....	9.34	.....	13,830	7,683	14,169	7,872	15,629	8,683	28	247
2.26	18.54	72.66	8.80	1.13	13,921	7,734	14,243	7,913	15,617	8,676	25	248
3.20	18.23	72.56	9.21	.87	13,757	7,643	14,212	7,896	15,654	8,697	5	249
2.58	20.40	72.27	7.33	.83	14,099	7,833	14,472	8,040	15,617	8,676	5	250
2.90	20.23	71.89	7.88	.93	13,982	7,768	14,400	8,000	15,632	8,684	5	251
3.29	19.83	71.95	8.22	.85	13,851	7,695	14,322	7,957	15,605	8,669	11	252
1.50	20.38	65.52	14.10	2.31	13,146	7,303	13,346	7,414	15,537	8,632	5	253
1.50	16.60	68.46	14.94	2.23	12,958	7,199	13,155	7,308	15,466	8,592	5	254
10.30	37.08	50.47	12.45	2.06	11,458	6,366	12,774	7,097	14,591	8,106	43	255
13.69	36.11	40.43	23.46	3.67	9,354	5,197	10,838	6,022	14,160	7,867	10	256
9.71	38.49	49.09	12.42	1.49	10,661	5,923	11,807	6,559	13,481	7,489	16	257
9.55	42.97	46.84	10.19	1.60	10,953	6,085	12,109	6,727	13,483	7,491	24	258
9.51	41.68	48.39	9.93	1.54	11,015	6,119	12,173	6,763	13,515	7,508	16	259
9.10	42.14	47.44	11.42	1.72	10,961	6,089	12,058	6,699	13,612	7,562	14	260
9.68	43.03	47.34	9.63	1.43	11,041	6,134	12,224	6,791	13,527	7,515	22	261
9.37	43.64	46.61	9.75	1.47	11,138	6,188	12,289	6,827	13,617	7,565	11	262
9.04	42.53	48.74	8.73	1.54	11,196	6,220	12,309	6,838	13,486	7,492	9	263
9.12	43.66	46.54	9.80	1.59	11,086	6,159	12,198	6,777	13,523	7,513	5	264
9.52	43.90	49.62	6.48	1.51	11,532	6,407	12,745	7,081	13,628	7,571	6	265
9.63	41.30	47.37	11.33	1.70	10,766	5,981	11,913	6,618	13,435	7,464	13	266
9.73	41.53	49.06	9.41	1.54	11,054	6,141	12,246	6,803	13,518	7,510	51	267

TABLE 2.—*Coals analyzed for the United States*

UNITED STATES COALS—Continued.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
MONTANA—Contd.					
CASCADE COUNTY.					
Sand Coulee	Nelson	Nelson	Nelson	Lump	150
Do	Sand Coulee		Sand Coulee	do	638
Do	Brown			Forked lump	119
PARK COUNTY.					
Chimney Rock	Maxey		Maxey	Lump	1,856
NEW MEXICO.					
COLFAX COUNTY.					
Dawson	Dawson	Raton	Dawson	Lump, over 4-inch screen.	150
Do	do	do	do	Lump, over 2-inch screen.	934
Do	do	do	do	do	1,547
Do	do	do	do	do	1,643
Do	do	do	do	Lump	978
Do	do	do	do	do	1,402
Do	do	do	do	do	1,195
Do	do	do	do	Run of mine	501
Koehler	Koehler	do	Swastika	Lump, over 1¼-inch screen.	1,984
Do	do	do	do	Lump, over 3-inch screen.	2,917
Do	do	do		Lump	3,123
M'KINLEY COUNTY.					
Allison	Diamond		Diamond	Lump, over 3-inch screen.	623
Do	do		Gallup	Lump, over 4½-inch screen.	1,043
Do	do		do	Lump, over 4-inch screen.	958
RIO ARRIBA COUNTY.					
Monero	Monero, No. 1			Run of mine	206
SANTA FE COUNTY.					
Madrid	No. 4		Cerillos	Anthracite egg	1,048
Do	do		do	do	601
Do	do		do	Anthracite large furnace.	600
Do	do		do	Anthracite small furnace.	1,365
Do	do		do	do	1,032
NORTH DAKOTA.					
WILLIAMS COUNTY.					
Williston	U. S. Reclamation Service.	Lignite		Crushed	314
OHIO.					
ATHENS COUNTY.					
Hocking	Eclipse	Hocking	Eclipse	Lump	196
Do	do	do	do	do	200
Do	do	do	do	do	248

Government during the fiscal years 1908–1915—Continued.

UNITED STATES COALS—Continued.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.
As received.	Dry coal.				As received.		Dry coal.		Moisture free and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B. t. u.	Calories.	B. t. u.	Calories.	B. t. u.	Calories.		
7	8	9	10	11	12	13	14	15	16	17	18	19
5.73	30.21	51.81	17.98	2.90	10,541	5,856	11,182	6,212	13,633	7,574	12	268
5.50	29.23	52.56	18.21	2.50	10,667	5,926	11,288	6,271	13,801	7,667	10	269
4.87	29.90	50.05	20.05	2.43	10,505	5,836	11,043	6,135	13,812	7,673	5	270
16.85	41.89	48.42	9.69	.47	9,956	5,531	11,974	6,652	13,259	7,366	12	271
1.78	36.84	47.83	15.33	.62	12,551	6,973	12,778	7,098	15,092	8,384	4	272
1.54	35.61	48.57	15.82	.77	12,441	6,912	12,636	7,020	15,011	8,339	8	273
1.74	36.34	48.15	15.51	.79	12,469	6,927	12,690	7,050	15,020	8,344	15	274
1.72	38.72	48.67	12.61	.62	12,952	7,196	13,179	7,322	15,081	8,378	13	275
1.74	37.59	48.02	14.39	.66	12,667	7,037	12,891	7,162	15,058	8,365	15	276
1.75	37.45	48.75	13.80	.62	12,748	7,082	12,975	7,208	15,052	8,362	11	277
1.86	37.18	48.52	14.30	.62	12,635	7,019	12,874	7,152	15,022	8,346	17	278
1.93	36.58	46.86	16.56	.69	12,256	6,809	12,497	6,943	14,977	8,321	11	279
1.69	38.52	53.96	7.52	.71	13,769	7,649	14,006	7,782	15,145	8,414	12	280
1.83	37.56	50.22	12.22	.70	12,932	7,184	13,173	7,318	15,007	8,337	9	281
1.75	39.26	52.76	7.98	.70	13,559	7,533	13,801	7,667	14,998	8,332	8	282
12.33	42.88	47.70	9.42	.57	11,101	6,167	12,662	7,034	13,979	7,766	6	283
13.11	46.84	47.52	5.64	.57	11,513	6,396	13,250	7,361	14,042	7,801	16	284
11.29	44.34	45.92	9.74	.52	11,199	6,222	12,611	7,006	13,972	7,762	6	285
2.92	40.98	52.65	6.37	.80	13,508	7,504	13,914	7,730	14,861	8,256	14	286
4.87	5.89	82.53	11.58	.74	12,445	6,914	13,082	7,268	14,795	8,219	13	287
5.23	5.22	81.75	13.03	.75	12,056	6,698	12,721	7,068	14,627	8,126	8	288
5.14	5.75	85.75	8.50	.74	12,790	7,106	13,483	7,491	14,736	8,187	11	289
4.57	6.76	83.94	9.30	.66	12,745	7,081	13,355	7,419	14,724	8,180	13	290
4.96	5.34	85.52	9.14	.68	12,654	7,030	13,313	7,396	14,652	8,140	10	291
40.95	47.08	42.03	10.89	1.37	6,367	3,537	10,782	5,990	12,100	6,722	13	292
2.55	36.54	55.90	7.56	1.15	13,619	7,566	13,975	7,764	15,118	8,399	20	293
2.26	36.94	54.07	8.99	1.16	13,451	7,473	13,762	7,646	15,121	8,401	19	294
2.20	39.70	52.20	8.10	1.71	13,577	7,543	13,882	7,712	15,106	8,392	13	295

TABLE 2.—*Coals analyzed for the United States*

UNITED STATES COALS—Continued.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
OHIO—Continued.					
HARRISON COUNTY.					
Blairmont	Majestic	Pittsburg, No. 8	Pittsburg, No. 8	Lump, over ½-inch screen.	999
HOCKING COUNTY.					
Longstreth	Stalter, No. 1	No. 6	Hocking Valley	Lump	3,424
Do	do	do	do	do	3,185
Do	do	do	do	do	3,305
JACKSON COUNTY.					
			Milton Jackson	Lump	395
OKLAHOMA.					
LE FLORE COUNTY.					
Bokoshe	Bokoshe	Panama	Bokoshe	Run of mine	350
Howe	Howe			do	305
OKMULGEE COUNTY.					
Dewar			Dewar	Lump, over 2-inch screen.	403
Do			do	Lump	224
Do			do	Run of mine	274
Henryetta	Henryetta		Henryetta	Lump	241
Do	do		do	Run of mine	1,682
PITTSBURG COUNTY.					
Adamson	Adamson	Hartshorne	Adamson	Lump, over 1-inch screen.	981
PITTSBURG AND LATIMER COUNTIES.					
			Adamson	Lump, over 1½-inch screen.	1,408
PENNSYLVANIA.					
ALLEGHENY COUNTY.					
Camden	Camden	Pittsburg		Through 1¼-inch bar screen.	1,516
Dravosburg	Risher	do	Youghlogheny	Lump, over ¾-inch screen.	1,211
Smithdale	Ocean, No. 5	do	do	Screenings	452
ARMSTRONG COUNTY.					
New Bethlehem	Fairmount			Run of mine	968
Do	do			do	986
CAMBRIA COUNTY					
Bakerton	Lancashire, No. 14	B or Miller	Lancashire	Run of mine	3,249
Do	do	do	do	do	426
Barnesboro	Delta	D or Lower Freeport	Delta	do	2,855
Do	do	do	do	do	10,578
Do	Empire "A"	do	Empire	do	7,650

Government during the fiscal years 1908–1915—Continued.

UNITED STATES COALS—Continued.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.
As received.	Dry coal.				As received.		Dry coal.		Moisture freed and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B. t. u.	Calories.	B. t. u.	Calories.	B. t. u.	Cal ries.		
7	8	9	10	11	12	13	14	15	16	17	18	19
2.6	43.4	49.4	7.2	3.55	13,266	7,370	13,620	7,567	14,677	8,154	1	296
6.27	39.69	52.68	7.63	1.86	12,606	7,004	13,451	7,473	14,562	8,090	30	297
6.60	40.90	51.50	7.60	2.00	12,548	6,971	13,435	7,464	14,540	8,078	21	298
6.30	41.10	48.30	10.60	3.43	12.129	6,738	12,944	7,191	14.479	8,044	21	299
9.28	.....	.....	9.61	.....	11,789	6,549	12,995	7,219	14,377	7,987	8	300
3.33	16.33	63.98	19.69	1.47	11,836	6,576	12,244	6,802	15,246	8,470	8	301
4.98	18.97	68.27	12.76	.98	12,851	7,139	13,525	7,514	15,503	8,613	5	302
6.34	34.74	55.96	9.30	2.45	12,434	6,908	13,276	7,376	14,637	8,132	10	303
6.08	37.15	55.35	7.50	2.21	12,738	7,077	13,563	7,535	14,663	8,146	4	304
6.46	36.00	53.04	10.96	2.12	12,186	6,770	13,028	7,238	14,632	8,129	5	305
6.68	37.85	54.47	7.68	1.79	12,620	7,011	13,523	7,513	14,648	8,138	4	306
6.46	36.59	53.61	9.80	2.00	12,346	6,859	13,199	7,333	14,633	8,129	13	307
2.40	36.28	54.99	8.73	1.30	13,400	7,445	13,730	7,628	15,043	8,357	12	308
2.14	38.80	51.95	9.25	.95	13,137	7,298	13,424	7,458	14,792	8,218	8	309
3.13	31.95	56.56	11.49	1.56	12,930	7,183	13,348	7,416	15,081	8,378	24	310
2.19	37.37	55.97	6.66	1.29	13,764	7,647	14,072	7,818	15,076	8,376	14	311
3.63	34.53	56.57	8.90	1.18	13.128	7,293	13,622	7,568	14,953	8,307	6	312
2.56	35.00	53.30	11.70	1.67	13,025	7,237	13,367	7,426	15,138	8,410	9	313
2.76	34.34	53.71	11.95	1.70	12,908	7,171	13,274	7,374	15,076	8,376	8	314
2.51	22.43	69.31	8.26	1.98	13,944	7,747	14,303	7,946	15,591	8,662	32	315
2.05	21.95	69.51	8.54	2.00	13,942	7,745	14,234	7,908	15,563	8,646	11	316
2.59	21.92	69.66	8.42	2.50	13,926	7,737	14,296	7,942	15,610	8,672	18	317
1.98	21.86	69.12	9.02	2.28	13,904	7,724	14,185	7,881	15,591	8,662	48	318
3.10	27.36	63.14	9.50	1.82	13,628	7,571	14,064	7,813	15,540	8,633	77	319

TABLE 2.—*Coals analyzed for the United States*

UNITED STATES COALS—Continued.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
PENNSYLVANIA—Continued.					
CAMBRIA COUNTY—continued.					
Colver	Ebensburg, No. 1.	B or Miller	Colver	Run of mine	75,635
Do	do	do	do	do	74,658
Do	do	do	do	do	63,120
Do	do	do	do	do	158,577
Do	do	do	do	do	44,790
Dunlo	Logan, No. 7	E or Upper Freeport.	Logan	do	6,995
Do	do	do	do	do	11,854
Do	do	do	do	do	1,456
Do	do	do	do	do	9,137
Do	do	do	do	do	8,161
Elmora	Sterling	B or Miller		do	23,391
Do	do	do		do	6,951
Do	do	do		do	15,403
Do	do	do		do	3,170
Do	do	do		do	30,358
Fallen Timber	Fallen Timber, No. 1.	E or Upper Freeport.	Colonial	do	20,375
Hastings	Rich Hill, Nos. 1 and 2.	do	Rich Hill	do	27,680
Johnstown	Bird	C′ or Upper Kittanning.	Bird Quemahoning.	do	10,898
Do	Valley, No. 1	do	Valley smokeless	do	494
Do	Morrellville	B or Miller	Morrellville	do	4,877
Nanty-Glo	Cardiff	do	Cardiff	do	6,679
Do	do	do	do	do	219
Do	do	do	do	do	1,759
Do	do	do	do	do	7,606
Do	do	do	do	do	3,215
Do	do	do	do	do	376
Do	do	do	do	do	6,780
Do	do	do	do	do	1,762
Do	do	do	do	do	1,371
Do	do	do	do	do	3,228
Do	do	do	do	do	490
Do	do	do	do	do	242
Do	do	do	do	do	1,254
Do	do	do	do	do	523
Do	do	do	do	do	1,308
Do	do	do	do	do	1,494
Do	Ivory Hill	do	Liberty	do	3,049
Do	Springfield, No. 1	do	Borman	do	7,000
Patton	Pardee		Beech Creek	do	1,585
Do	do		Pardee	do	4,858
Portage	Aetna	E or Upper Freeport.		do	194
Do	do	do		do	190
Do	Miller Shaft, No. 1	B or Miller	South Fork	do	5,075
Saxman	Greenwich	D or Lower Freeport.	Greenwich	do	4,057
South Fork	Argyle	B or Miller	Argyle	do	12,387
Do	do	do	do	do	16
Twin Rocks	Ben Par	do	Ben Par	do	5,248
Do	Big Bend	do	Davenport	do	3,158
Do		do	do	do	3,200
Do	Commercial, Nos. 3, 4, and 5.	do	Star	do	15,705
Do	Commercial	do	do	do	3,362
Do	do	do	do	do	583
Do	do	do	do	do	1,061
Do	do	do	do	do	362
Do	do	do	do	do	7,411
Do	Nonpareil	do	Big Bend	do	468
Do	do	do	do	do	1,018

Government during the fiscal years 1908–1915—Continued.

UNITED STATES COALS—Continued.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.
As received.	Dry coal.				As received.		Dry coal.		Moisture free and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B. t. u.	Calories.	B. t. u.	Calories.	B. t. u.	Calories.		
7	8	9	10	11	12	13	14	15	16	17	18	19
2.53	22.18	70.33	7.49	1.55	14,127	7,848	14,494	8,052	15,667	8,704	335	320
2.21	22.97	69.37	7.66	1.61	14,137	7,854	14,456	8,031	15,655	8,697	332	321
1.97	22.88	69.85	7.27	1.68	14,201	7,889	14,486	8,048	15,622	8,679	278	322
2.09	23.25	70.37	6.38	1.42	14,337	7,965	14,643	8,135	15,641	8,689	78	323
2.23	23.20	70.52	6.28	1.40	14,328	7,960	14,655	8,142	15,637	8,687	63	324
3.23	17.83	71.37	10.80	2.38	13,470	7,483	13,920	7,733	15,605	8,669	48	325
2.50	19.91	72.14	7.95	1.85	14,076	7,820	14,437	8,021	15,684	8,713	90	326
2.28	19.13	71.37	9.50	1.87	13,824	7,680	14,147	7,859	15,632	8,684	13	327
2.64	19.12	71.87	9.01	1.89	13,854	7,697	14,230	7,906	15,639	8,688	45	328
2.56	18.22	72.03	9.75	2.32	13,713	7,618	14,073	7,818	15,593	8,663	31	329
2.43	19.91	72.29	7.80	1.73	14,119	7,844	14,471	8,039	15,695	8,719	161	330
3.11	21.66	70.48	7.86	1.67	13,977	7,765	14,426	8,014	15,657	8,698	45	331
2.69	23.15	68.64	8.21	1.77	13,909	7,761	14,355	7,975	15,639	8,688	90	332
2.64	22.73	68.67	8.60	1.88	13,880	7,711	14,256	7,920	15,597	8,665	12	333
2.03	22.57	68.97	8.46	1.85	14,012	7,784	14,302	7,946	15,624	8,680	26	334
2.29	26.01	65.41	8.58	1.22	13,920	7,733	14,246	7,914	15,583	8,657	36	335
2.48	25.51	67.46	7.03	1.03	14,119	7,844	14,478	8,043	15,573	8,652	47	336
1.99	16.39	72.81	10.80	1.85	13,591	7,551	13,867	7,704	15,546	8,637	33	337
1.30	20.14	71.73	8.13	.94	14,165	7,869	14.352	7,973	15.622	8,679	11	338
3.51	22.10	68.71	9.19	1.96	13.650	7,583	14.147	7,859	15.579	8.655	24	339
2.12	.....	.....	6.72	.....	14,360	7,978	14.671	8.151	15 728	8.738	157	340
2.25	20.22	73.48	6.30	2.05	14.336	7,964	14,666	8,148	15 652	8,696	12	341
2.08	20 28	73.25	6.47	1.91	14.331	7,962	14,635	8.131	15 647	8.693	28	342
2.09	19 56	73.75	6.69	1.99	14.369	7,983	14.676	8 153	15.728	8.738	142	343
2.26	20 05	73.00	6.95	2.11	14,284	7,936	14,614	8.119	15 706	8.726	46	344
2.00	20 30	72.76	6.94	2.16	14,274	7.930	14.565	8.092	15,651	8.695	24	345
2.16	21 08	69.81	9.11	1.79	13,911	7.728	14,218	7.899	15 643	8,691	20	346
2.17	21.42	71.62	6.96	2.13	14,261	7,923	14,577	8.098	15,667	8,704	33	347
2.06	20.72	72.27	7.01	1.97	14,311	7,951	14,612	8,118	15.714	8.731	27	348
2.28	20.96	71.89	7.15	2.07	14,222	7,901	14.554	8.086	15.675	8.708	51	349
1.93	20.14	72.13	7.73	2.07	14,165	7,869	14.444	8.024	15.654	8.697	20	350
1.99	20.67	72.26	7.07	2.09	14,249	7,916	14.538	8.077	15.644	8.691	7	351
2.24	22.42	70.79	6.79	2.05	14,292	7,940	14.619	8.122	15.684	8,713	16	352
1.82	21.56	71.13	7.31	2.09	14,213	7,896	14.476	8.042	15.618	8.677	13	353
2.89	22 14	70.69	7.17	1.88	14.105	7,836	14.525	8,069	15 647	8.693	16	354
2.08	22 71	70.70	6.59	2.10	14,288	7,938	14,592	8.107	15.621	8,678	20	355
2.58	20.72	71.67	7.61	2.12	14 080	7,822	14,453	8.029	15.643	8,691	32	356
2.34	20.18	71.58	8.24	2.41	13,992	7,773	14.327	7,959	15.614	8,674	24	357
2.42	20.81	71.87	7.32	1.13	14,087	7,826	14 436	8.020	15.576	8,653	12	358
3.15	23.26	68.73	8.01	1.35	13,887	7,715	14.339	7.966	15,588	8.660	77	359
1.42	20.03	72.78	7.19	1.72	14,399	7,999	14,606	8,114	15,738	8,743	4	360
2.00	19.04	71.96	9.00	2.13	13,948	7,749	14.233	7,907	15,641	8,689	6	361
2.87	17.23	75.49	7.28	.84	14,060	7,811	14.475	8.042	15,612	8,673	18	362
3.14	26.37	64.99	8.64	1.45	13,788	7,660	14,235	7,908	15,581	8,656	63	363
1.99	17.59	74.63	7.78	1.35	14,170	7,872	14.458	8,032	15.678	8.710	38	364
1.43	.....	.....	6.72	.....	14.323	7,958	14,531	8,073	15,578	8,654	4	365
3.10	19.73	73.40	6.87	1.75	14.161	7,867	14,614	8.119	15,692	8,718	23	366
2.78	21.27	72.13	6.60	1.78	14.147	7,859	14,552	8.084	15.580	8,656	6	367
4.86	21.55	71.80	6.65	1.34	13,754	7,641	14.457	8.032	15.487	8,604	14	368
2.56	21.60	71.18	7.22	2.18	14,140	7,856	14,511	8,062	15,640	8,689	53	369
3.05	20.48	72.45	7.07	1.85	14,121	7,845	14,565	8.092	15.673	8,707	24	370
1.83	.....	.....	7.76	.....	14,259	7,922	14.525	8,069	15.747	8,748	13	371
2.26	19.37	73.16	7.47	1.73	14,222	7.901	14,551	8,084	15,726	8,737	41	372
2.60	19.53	73.33	7.14	1.57	14,216	7,898	14.595	8,108	15,717	8,732	18	373
2.00	19.40	73.57	7.03	2.17	14,338	7,966	14,631	8,128	15,737	8,743	61	374
2.59	22.57	70.80	6.63	1.88	14,240	7,911	14,619	8,122	15,657	8,698	16	375
2.71	22.65	71.23	6.12	1.85	14,254	7,919	14,651	8,139	15,606	8,670	27	376

TABLE 2.—*Coals analyzed for the United States*

UNITED STATES COALS—Continued.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
PENNSYLVANIA—Continued.					
CAMBRIA COUNTY—continued.					
Vintondale	Vinton	B or Miller	Vinton	Run of mine	1,791
Do	do	do	do	do	2,292
Do	do	do	do	do	10,423
Do	do	do	do	do	9,796
CLEARFIELD COUNTY.					
Hawk Run	Acme	B or Miller	Acme	Run of mine	483
Do	do	do	do	do	3,376
Do	do	do	do	do	2,067
Do	do	do	do	do	1,520
Do	do	do	do	do	3,260
Do	do	do	do	do	3,250
Do	do	do	do	do	3,301
Do	do	do	do	do	6,780
Do	do	do	do	do	8,684
Do	do	do	do	do	3,114
Do	do	do	do	do	2,392
Irvona	Irvona	do	Irvona	do	748
Do	do	do	do	do	3,050
Ramey	Whitney	do	Whitney	do	391
Do	Bulah, No. 4	D or Lower Freeport.	Bulah	do	3,370
Smith Mills	Viola	B or Miller	Viola	do	2,420
ELK AND JEFFERSON COUNTIES.					
	Shawmut	D or Lower Freeport.	Shawmut	Lump, over ¾-inch screen.	996
FAYETTE COUNTY.					
Braznell	Braznell		Youghiogheny	Screenings	8,018
Brownsville Junction.	Pike	Pittsburgh		Slack and nut	1,619
HUNTINGDON COUNTY.					
Robertsdale	Robertsdale and Woodvale.	Barnett and Fulton.	Rockhill	Run of mine	64,372
Do	do	do	do	do	14,365
INDIANA COUNTY.					
Clymer	Empire	B or Miller	Empire	Run of mine	7,245
Graceton	Graceton	E or Upper Freeport.	Graceton	do	1,198
JEFFERSON COUNTY.					
Delancey and Eleanora.	Florence and Eleanora.	D or Lower Freeport.		Run of mine	894
Do	do	do		Lump, over ¾-inch screen.	901
Do	Adrian and Eleanora.	do		Run of mine	898
Eleanora	Eleanora	do			1,172

Government during the fiscal years 1908–1915—Continued.

UNITED STATES COALS—Continued.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.
As received.	Dry coal.				As received.		Dry coal.		Moisture free and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B. t. u.	Calories.	B. t. u.	Calories.	B. t. u.	Calories.		
7	8	9	10	11	12	13	14	15	16	17	18	19
2.18	.....	.....	7.84	.....	14,130	7,850	14,445	8,025	15,674	8,708	13	377
2.24	19.25	72.65	8.10	2.57	14,068	7,816	14,390	7,994	15,658	8,699	38	378
2.27	19.58	73.19	7.23	2.26	14,253	7,918	14,584	8,102	15,721	8,734	229	379
2.23	20.89	70.96	8.15	2.37	14,065	7,814	14,386	7,992	15,662	8,701	166	380
2.33	21.01	71.18	7.81	2.16	14,140	7,856	14,477	8,043	15,703	8,724	11	381
2.56	21.55	70.36	8.09	2.25	14,054	7,808	14,423	8,013	15,693	8,718	23	382
2.58	.....	.....	7.93	.....	14,022	7,790	14,393	7,996	15,633	8,685	9	383
1.92	.....	.....	9.63	.....	13,861	7,701	14,132	7,851	15,638	8,688	9	384
2.96	21.38	68.17	10.45	2.42	13,516	7,509	13,928	7,738	15,553	8,641	90	385
3.10	21.70	67.36	10.94	2.51	13,401	7,445	13,830	7,683	15,529	8,627	50	386
3.12	22.71	67.52	9.77	2.48	13,616	7,564	14,054	7,808	15,576	8,653	94	387
2.42	22.59	67.84	9.57	2.42	13,728	7,627	14,068	7,816	15,557	8,643	115	388
2.72	22.18	68.77	9.05	2.27	13,745	7,636	14,129	7,849	15,535	8,631	79	389
3.06	22.48	67.72	9.80	2.32	13,574	7,541	14,002	7,779	15,523	8,624	23	390
3.51	22.04	68.52	9.44	2.60	13,546	7,526	14,039	7,799	15,502	8,612	27	391
2.36	.....	.....	9.34	.....	13,898	7,721	14,234	7,908	15,700	8,722	17	392
2.38	.....	.....	11.63	.....	13,493	7,496	13,822	7,679	15,641	8,689	62	393
2.89	22.57	69.43	8.00	1.35	13,968	7,760	14,384	7,991	15,635	8,686	16	394
3.60	16.44	78.02	5.54	.64	14,273	7,929	14,806	8,226	15,674	8,708	38	395
3.01	.....	.....	8.35	.....	13,944	7,747	14,377	7,987	15,687	8,715	55	396
4.06	34.15	56.25	9.60	1.94	13,210	7,339	13,769	7,649	15,231	8,462	18	397
5.37	30.76	58.39	10.85	1.66	12,675	7,042	13,394	7,441	15,024	8,347	35	398
3.59	32.16	56.61	11.23	1.38	12,937	7,187	13,419	7,455	15,117	8,398	24	399
2.03	15.98	75.20	8.82	1.35	14,024	7,791	14,315	7,953	15,700	8,722	397	400
1.89	15.95	74.01	10.04	1.22	13,814	7,674	14,080	7,822	15,651	8,695	36	401
3.24	28.30	62.81	8.89	2.07	13,669	7,594	14,127	7,848	15,505	8,614	47	402
1.96	25.12	65.50	9.38	1.34	13,775	7,653	14,050	7,806	15,504	8,613	5	403
3.04	30.72	62.76	6.52	1.27	14,040	7,800	14,480	8,044	15,490	8,606	13	404
2.81	30.50	62.43	7.07	1.68	13,977	7,765	14,381	7,989	15,475	8,597	24	405
2.27	31.87	59.02	9.11	1.76	13,737	7,632	14,056	7,809	15,465	8,592	9	406
3.91	32.03	59.54	8.43	1.82	13,582	7,546	14,135	7,853	15,436	8,576	31	407

TABLE 2.—*Coals analyzed for the United States*

UNITED STATES COALS—Continued.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
PENNSYLVANIA—Continued.					
SOMERSET COUNTY.					
Boswell	Atlantic	C' or Upper Kittanning.		Run of mine	6,489
Do	do	do		do	614
Do	Orenda	do	Orenda	do	73,027
Do	do	do	do	do	2,000
Do	do	do	do	do	5,784
Do	do	do	do	do	
Do	do	do	do	do	3,812
Do	do	do	do	do	5,915
Do	do	do	do	do	540
Do	do	do	do	do	540
Do	do	do	do	do	2,766
Do	do	do	do	do	3,597
Do	do	do	do	do	6,644
Do	do	do	do	do	3,445
Do	do	do	do	do	6,845
Do	do	do	do	do	1,316
Boswell and Jerome.	Orenda and Jerome.	do	Orenda and Jerome.	do	3,959
Do	do	do	do	do	1,523
Elk Lick	Pine Hill and Elk Lick.	Pittsburgh		do	2,559
Do	do	do		do	10,155
Do	Merchants, No. 3	do		do	19,694
Garrett	Garrett	C' or Upper Kittanning.	Powell	do	6,378
Hooversville	Knickerbocker	B or Miller	Knickerbocker	do	3,972
Do	do	do	do	do	148
Do	do	do	do	do	623
Do	Landstreet	do	Margaret	do	6,341
Jenner	Consolidation	C' or Upper Kittanning.	Jenner	do	427
Do	do	do	do	do	5,200
Do	do	do	do	do	6,200
Do	do	do	do	do	3,250
Do	do	do	do	do	6,563
Do	do	do	do	do	1,310
Do	do	do	do	do	12,834
Do	do	do	do	do	5,700
Do	do	do	do	do	5,900
Do	do	do	do	do	6,207
Do	do	do	do	do	358
Do	do	do	do	do	3,445
Do	do	do	do	do	3,747
Do	do	do	do	do	7,300
Do	do	do	do	do	5,820
Do	do	do	do	do	6,916
Do	do	do	do	do	6,300
Do	do	do	do	do	4,592
Do	do	do	do	do	3,595
Do	do	do	do	do	1,336
Jerome	Jerome	do		Lump, over 3-inch bar screen.	389
Macdonaldton	Pen Mar, Nos. 2 and 3.	B or Miller	Pen Mar	Run of mine	604
Do	do	do	do	do	1,115
Do	do	do	do	do	3,169
Do	do	do	do	do	680
Do	do	do	do	do	906
Do	do	do	do	do	677
Do	do	do	do	do	2,934
Do	do	do	do	do	2,298
Do	do	do	do	do	1,027
Zimmerman	Quemahoning Creek No. 1.	C' or Upper Kittanning.	Quemahoning Creek.	do	11,126

Government during the fiscal years 1908–1915—Continued.

UNITED STATES COALS—Continued.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.
As received.	Dry coal.				As received.		Dry coal.		Moisture free and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B. t. u.	Calories.	B. t. u.	Calories.	B. t. u.	Calories.		
7	8	9	10	11	12	13	14	15	16	17	18	19
2.80	17.29	73.51	9.20	0.91	13,834	7,686	14,233	7,909	15,675	8,708	34	408
3.91	18.16	73.02	8.82	.93	13,688	7,604	14,245	7,914	15,623	8,679	10	409
2.56	16.90	73.46	9.64	.95	13,747	7,637	14,108	7,838	15,613	8,674	644	410
2.68	.....	.....	9.07	.....	13,880	7,711	14,262	7,923	15,685	8,714	51	411
2.60	.....	.....	8.97	.....	13,917	7,732	14,289	7,938	15,697	8,721	67	412
2.75	.....	.....	9.24	.....	13,771	7,651	14,160	7,867	15,602	8,668	26	413
2.45	.....	.....	9.84	.....	13,718	7,621	14,063	7,813	15,598	8,666	106	414
2.26	.....	.....	9.95	.....	13,742	7,634	14,060	7,811	15,614	8,674	88	415
2.58	.....	.....	9.69	.....	13,851	6,695	14,218	7,899	15,744	8,747	11	416
2.33	.....	.....	9.71	.....	13,764	7,647	14,092	7,829	15,607	8,671	17	417
1.86	15.64	74.65	9.71	.86	13,871	7,706	14,134	7,852	15,654	8,697	62	418
2.23	.....	.....	9.60	.....	13,807	7,671	14,122	7,846	15,622	8,679	44	419
2.52	.....	.....	9.82	.....	13,745	7,636	14,100	7,833	15,635	8,686	113	420
2.37	.....	.....	9.67	.....	13,762	7,646	14,096	7,831	15,605	8,669	49	421
2.63	.....	.....	9.78	.....	13,708	7,616	14,078	7,821	15,604	8,669	71	422
1.52	17.04	71.96	11.00	.90	13,637	7,576	13,847	7,693	15,558	8,643	9	423
1.69	16.95	72.32	10.73	.99	13,661	7,589	13,896	7,720	15,566	8,648	20	424
1.33	17.17	73.22	9.61	.89	13,892	7,718	14,079	7,822	15,576	8,653	7	425
2.47	20.36	72.93	6.71	1.31	14,284	7,936	14,646	8,137	15,699	8,722	11	426
2.43	21.41	72.62	5.97	1.22	14,399	7,999	14,758	8,199	15,695	8,719	44	427
2.84	16.65	74.57	8.78	.92	13,869	7,705	14,274	7,930	15,648	8,693	98	428
3.07	19.40	70.05	10.55	2.31	13,468	7,482	13,895	7,719	15,534	8,630	41	429
2.57	17.21	72.49	10.30	1.68	13,651	7,584	14,011	7,784	15,620	8,678	9	430
2.08	18.07	71.26	10.67	1.07	13,695	7,608	13,986	7,770	15,657	8,698	4	431
2.00	20.17	72.39	7.44	1.76	14,191	7,884	14,481	8,045	15,645	8,692	12	432
3.12	17.24	74.48	8.28	1.99	13,811	7,673	14,256	7,920	15,543	8,635	24	433
2.21	.....	.....	9.51	.....	13,884	7,713	14,198	7,888	15,690	8,717	13	434
2.84	.....	.....	9.22	.....	13,816	7,676	14,220	7,900	15,664	8,702	79	435
2.82	.....	.....	9.94	.....	13,662	7,590	14,058	7,810	15,610	8,672	63	436
2.04	17.64	72.28	10.08	1.37	13,740	7,633	14,026	7,792	15,598	8,666	17	437
2.22	17.72	72.19	10.09	1.38	13,716	7,620	14,027	7,793	15,601	8,667	28	438
1.94	17.98	74.15	7.87	.80	14,133	7,852	14,413	8,007	15,644	8,691	8	439
2.26	18.15	71.85	10.00	1.44	13,710	7,617	14,027	7,793	15,586	8,659	46	440
2.51	17.59	72.07	10.34	1.59	13,622	7,567	13,973	7,764	15,584	8,658	24	441
2.12	17.62	71.87	10.51	1.47	13,661	7,589	13,957	7,755	15,596	8,664	28	442
1.82	17.61	72.15	10.24	1.38	13,712	7,618	13,966	7,759	15,559	8,644	20	443
1.57	17.80	71.40	10.80	1.48	13,685	7,603	13,903	7,724	15,586	8,659	3	444
2.11	18.00	71.32	10.68	1.68	13,617	7,565	13,911	7,728	15,574	8,652	14	445
1.52	17.86	71.69	10.45	1.62	13,721	7,623	13,933	7,741	15,559	8,644	14	446
1.99	18.13	71.66	10.21	1.56	13,718	7,621	13,997	7,776	15,589	8,661	24	447
2.39	18.01	71.90	10.09	1.59	13,649	7,583	13,983	7,768	15,552	8,640	18	448
1.89	17.36	72.56	10.08	1.57	13,706	7,614	13,970	7,761	15,536	8,631	23	449
2.42	17.76	72.12	10.12	1.67	13,608	7,560	13,945	7,747	15,515	8,619	24	450
1.60	17.02	72.45	10.53	1.36	13,678	7,599	13,900	7,722	15,536	8,631	14	451
2.11	17.52	72.82	9.66	1.51	13,748	7,638	14,044	7,802	15,546	8,637	14	452
1.55	17.33	72.67	10.00	1.46	13,761	7,645	13,978	7,766	15,531	8,628	8	453
3.52	15.43	75.89	8.68	.92	13,773	7,652	14,275	7,931	15,632	8,684	12	454
3.05	16.17	72.58	11.25	1.93	13,398	7,443	13,820	7,678	15,572	8,651	3	455
2.66	17.78	70.79	11.43	2.02	13,391	7,439	13,757	7,643	15,532	8,629	10	456
2.04	18.52	71.62	9.86	1.74	13,736	7,631	14,022	7,790	15,556	8,642	92	457
2.95	16.62	72.18	11.20	2.01	13,390	7,439	13,797	7,665	15,537	8,632	6	458
2.75	18.53	70.15	11.32	2.18	13,365	7,425	13,743	7,635	15,497	8,609	30	459
3.22	18.08	69.52	12.40	2.34	13,072	7,262	13,507	7,504	15,419	8,566	16	460
3.23	18.46	69.96	11.58	2.13	13,198	7,332	13,639	7,577	15,425	8,569	43	461
3.15	17.89	70.49	11.62	2.26	13,204	7,336	13,633	7,574	15,425	8,569	49	462
2.77	17.99	70.18	11.83	2.24	13,184	7,324	13,560	7,533	15,379	8,544	16	463
2.57	17.49	71.39	11.12	1.61	13,469	7,483	13,824	7,680	15,554	8,641	51	464

TABLE 2.—*Coals analyzed for the United States*

UNITED STATES COALS—Continued.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
PENNSYLVANIA—Continued.					
WASHINGTON COUNTY.					
Baird and Hazel Kirk.	Schoenberger and Hazel Kirk.	Pittsburgh	Youghiogheny	Lump	450
California	Crescent	do	do	Through 1¼-inch screen.	1,064
Hazel Kirk	Hazel Kirk	do	do	Screenings	8,597
West Brownsville	Diamond	do	Pittsburgh	Lump, over 2½-inch screen.	446
Do	do	do	do	do	376
WASHINGTON AND ALLEGHENY COUNTIES.					
Monongahela and Gallatin.	Black Diamond and Sunnyside.	Pittsburgh	Youghiogheny	Lump, over 2-inch screen.	18,382
WESTMORELAND COUNTY.					
Adamsburg	Edna	Pittsburgh	Youghiogheny	Through 1¼-inch screen.	1,008
Seward	Ninevah	B or Miller	Ninevah	Run of mine	3,154
Webster	Budd	Pittsburgh	Youghiogheny	Lump	1,004
		do	do	Run of mine	790
		do	do	Lump, over 2-inch screen.	3,480
		do	do	Lump	262
		do	do	Lump, over 1¼-inch screen.	292
		do	do	Lump	641
		do	do	do	636
		do	do	do	707
Wyano	Osborne	do	do	Screenings	1,173
		do	do	do	449
		do	do	do	8,101
		do	do	do	927
		do	do	do	415
		do	do	do	1,146
		do	do	do	914
			do	do	1,026
TENNESSEE.					
ANDERSON COUNTY.					
Briceville	Crass Mountain	Coal Creek	Crass Mountain	Run of mine	1,715
CAMPBELL COUNTY.					
Caryville	Bear Wallow	Coal Creek	Bear Wallow	Run of mine	5,040
CLAIBORNE COUNTY.					
Clairfield	King Mountain	Jellico		Run of mine	2,623
MORGAN COUNTY.					
Coalfield	Baker	Coal Creek	Round Mountain	Run of mine	3,473
SEQUATCHIE COUNTY.					
Dunlap	Dunlap	Sewanee	Dunlap	Run of mine	4,364

Government during the fiscal years 1908–1915—Continued.

UNITED STATES COALS—Continued.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.
As received.	Dry coal.				As received.		Dry coal.		Moisture free and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B. t. u.	Calories.	B. t. u.	Calories.	B. t. u.	Calories.		
7	8	9	10	11	12	13	14	15	16	17	18	19
1.82	36.18	57.12	6.70	1.26	13,996	7,776	14,255	7,919	15,279	8,488	8	465
4.54	33.40	54.71	11.89	1.47	12,562	6,979	13,159	7,311	14,935	8,297	10	466
7.49	32.87	56.87	10.26	2.51	12,378	6,877	13,380	7,433	14,910	8,283	33	467
3.14	33.93	57.29	8.78	1.05	13,452	7,473	13,888	7,716	15,225	8,458	8	468
2.08	34.95	54.77	10.28	.94	13,369	7,427	13,653	7,585	15,217	8,454	7	469
2.20	35.69	56.35	7.96	1.02	13,657	7,587	13,964	7,758	15,172	8,429	19	470
4.39	34.53	55.68	9.79	1.84	13,016	7,231	13,614	7,563	15,091	8,384	11	471
2.15	23.19	69.17	7.64	1.82	14,100	7,833	14,410	8,006	15,602	8,668	30	472
2.10	35.77	56.02	8.21	1.76	13,665	7,592	13,948	7,749	15,196	8,442	6	473
2.98	35.20	57.35	7.45	1.35	13,539	7,522	13,955	7,753	15,078	8,377	10	474
1.89	34.85	60.01	5.14	.93	14,248	7,916	14,522	8,068	15,309	8,505	17	475
2.15	35.96	56.82	7.22	1.63	13,753	7,611	14,055	7,808	15,149	8,416	9	476
1.83	35.76	55.48	8.76	.76	13,618	7,566	13,872	7,707	15,204	8,447	4	477
2.70	36.20	56.02	7.78	1.55	13,535	7,519	13,911	7,728	15,085	8,381	11	478
1.84	36.51	58.16	5.33	.75	14,179	7,877	14,445	8,025	15,258	8,477	17	479
1.98	36.54	56.88	6.58	.89	13,964	7,758	14,246	7,914	15,249	8,472	10	480
5.58	33.55	55.57	10.88	1.33	12,533	6,963	13,274	7,374	14,895	8,275	22	481
4.33	34.42	55.87	9.71	1.37	12,988	7,216	13,576	7,542	15,036	8,353	6	482
4.55	33.52	54.88	11.60	1.49	12,637	7,021	13,239	7,356	14,976	8,320	29	483
4.54	34.65	55.20	10.15	1.70	12,906	7,170	13,520	7,511	15,047	8,359	10	484
4.33	34.56	57.06	8.38	.92	13,228	7,349	13,827	7,682	15,092	8,384	7	485
4.89	31.43	57.96	10.61	1.46	12,839	7,133	13,499	7,499	15,101	8,389	11	486
4.44	33.50	57.83	8.67	1.44	13,251	7,362	13,867	7,704	15,183	8,435	18	487
5.19	36.20	54.75	9.05	1.04	12,851	7,139	13,554	7,530	14,903	8,279	11	488
2.20	36.33	55.25	8.42	1.19	13,609	7,561	13,915	7,731	15,194	8,441	7	489
2.01	36.37	56.16	7.47	.91	13,671	7,595	13,951	7,751	15,077	8,376	13	490
2.00	35.40	50.86	13.74	1.99	12,674	7,041	12,933	7,185	14,993	8,329	7	491
1.98	37.81	50.80	11.39	3.37	13,179	7,322	13,445	7,469	15,173	8,429	21	492
2.05	30.96	58.91	10.13	1.26	13,472	7,484	13,754	7,641	15,304	8,502	39	493

TABLE 2.—*Coals analyzed for the United States.*

UNITED STATES COALS—Continued.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
TEXAS.					
MAVERICK COUNTY.					
Eagle Pass	International	Eagle Pass	Eagle Pass	Lump	4,600
WEBB COUNTY.					
Cannel and San Jose.	Cannel, San Jose, and No. 3.	San Pedro	Cannel	Run of mine	462
UTAH.					
CARBON COUNTY.					
Black Hawk	Black Hawk	Book Cliff	Black Hawk	Lump	1,300
Castle Gate	Castle Gate	Castle Gate	Castle Gate	Lump, over 4½-inch round-hole screen.	3,750
Hiawatha	Hiawatha	Book Cliff	Hiawatha	Lump	300
Kenilworth		Aberdeen	Aberdeen	Lump, over 4-inch shaking screen.	939
EMERY COUNTY.					
Mohrland	Mohrland	Book Cliff	King	Lump, over 3-inch round-hole screen.	3,510
VIRGINIA.					
RUSSELL COUNTY.					
Dante	Nos. 2 and 5	Upper Banner.	Clinchfield	Run of mine	183
RUSSELL AND WISE COUNTIES.					
Dante and Wilder.	Nos. 2, 5, 6, 52, and 55.	Upper and Lower Banner.	Clinchfield	Run of mine (steam).	1,220
Dante, Slemp, and Toms Cree		do	do	Run of mine	4,466
			do	do	1,497
			do	do	1,289
			do	do	1,528
			do	do	11,903
			do	do	10,011
			do	do	2,273
			do	Stoker	3,418
			do	Sized steam	6,239
TAZEWELL COUNTY.					
Pocahontas	Big Vein, Nos. 1 and 2.	Pocahontas, No. 3.	Pocahontas	Run of mine	13,668
Do	do	do	do	do	1,834
Do	do	do	do	do	15,573

Government during the fiscal years 1908–1915—Continued.

UNITED STATES COALS—Continued.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.
As received.	Dry coal.				As received.		Dry coal.		Moisture free and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B. t. u.	Calories.	B. t. u.	Calories.	B. t. u.	Calories.		
7	8	9	10	11	12	13	14	15	16	17	18	19
7.10	37.73	47.02	15.25	1.00	11,323	6,291	12,188	6,771	14,381	7,989	33	494
4.45	42.54	36.88	20.58	2.87	10,889	6,049	11,396	6,331	14,349	7,972	10	495
4.57	46.76	46.88	6.36	.61	12,985	7,214	13,607	7,559	14,531	8,073	12	496
3.83	43.50	50.68	5.82	.52	13,048	7,249	13,568	7,538	14,406	8,003	28	497
5.13	45.17	48.96	5.87	.65	12,959	7,199	13,660	7,589	14,512	8,062	3	498
4.94	42.39	51.32	6.29	.58	12,686	7,048	13,345	7,414	14,241	7,912	8	499
4.65	45.53	48.21	6.26	.64	13,011	7,228	13,646	7,581	14,557	8,087	35	500
2.65	35.50	57.45	7.05	.68	14,073	7,818	14,456	8,031	15,552	8,640	4	501
2.22	36.94	54.41	8.65	.70	13,697	7,609	14,008	7,782	15,334	8,519	14	502
2.04	36.72	55.08	8.20	.56	13,799	7,666	14,086	7,826	15,344	8,524	23	503
2.03	34.51	55.67	9.82	.70	13,579	7,544	13,860	7,700	15,369	8,538	29	504
1.75	34.17	58.22	7.61	.64	13,997	7,776	14,246	7,914	15,419	8,566	23	505
2.38	34.55	55.82	9.63	.72	13,566	7,537	13,897	7,721	15,378	8,543	13	506
2.43	35.22	56.21	8.57	.63	13,692	7,607	14,033	7,796	15,348	8,527	42	507
1.47	36.23	56.53	7.24	.57	14,093	7,829	14,303	7,946	15,419	8,566	16	508
1.57	35.87	56.21	7.92	.57	13,947	7,748	14,169	7,872	15,388	8,549	12	509
1.64	36.29	54.91	8.80	.59	13,813	7,674	14,043	7,802	15,398	8,554	32	510
2.43	36.15	52.11	11.74	.64	13,154	7,308	13,482	7,490	15,275	8,487	32	511
3.03	20.93	73.66	5.41	.68	14,479	8,044	14,931	8,295	15,785	8,769	160	512
1.49	20.19	73.91	5.90	.72	14,581	8,101	14,802	8,223	15,730	8,739	8	513
3.12	20.08	74.94	4.98	.67	14,557	8,087	15,026	8,348	15,814	8,786	207	514

TABLE 2.—*Coals analyzed for the United States*

UNITED STATES COALS—Continued.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
WASHINGTON.					
KING COUNTY.					
Black Diamond	Black Diamond	McKay	Black Diamond	Run of mine	1,888
Do	do	do	do	do	1,576
Coal Creek	Newcastle	No. 4	Newcastle	Lump, over 2-inch screen.	2,425
Do	do	do	do	do	2,664
Do	do	do	do	do	1,783
Do	do	do	do	do	1,471
Do	do		do	Lump, over 2-inch shaking screen.	995
Do	do		do	do	1,000
KITTITAS COUNTY.					
Roslyn	Beekman	Roslyn	Roslyn	Lump, over 1¼-inch screen.	3,444
Do	do	do	do	Steam	261
Do	do	do	do	do	3,095
Do	do	do	do	do	2,281
Do	Patrick-MacKay	do	Roslyn-Cascade	Lump	2,369
Do	do	do	do	do	3,255
Do	do	do	do	do	1,055
Do	do	do	do	Steam	729
Do	do	do	do	Run of mine	668
Do	Roslyn-Cascade[a]	do	do	do	796
Do	do	do	do	Lump, over 2-inch bar screen.	895
Do	Roslyn	Roslyn	Roslyn-Cascade	Lump	737
Do	do	do	do	Washed steam	3,029
PIERCE COUNTY.					
Burnett	Burnett	Nos. 1, 2, and 3	South Prairie	Lump	799
Do	do	do	do	do	1,050
Do	do	do	do	Lump, over 2-inch bar screen.	1,757
Do	do	do	do	Washed steam	666
Do	do	do	do	do	933
Do	do	do	do	Run of mine	587
Do	do	do	do	do	147
Do	do	do	do	do	536
Do	do	do	do	do	339
Do	do	do	do	do	8,343
Carbonado	Carbonado	Wingate	Carbonado	Washed steam	639
Do	do	do	do	do	4,568
Do	do	do	do	do	8,880
Do	do	do	do	do	2,479
Do	do	do	do	Lump, over 1¼-inch bar screen.	1,230
Do	Carbon Hill	do	do	do	1,091
Wilkeson	Gale Creek	Queen	Gale Creek	Lump	798
Do	do	do	do	Steam	592
Do	do	do	do	Washed through 2½-inch round-hole shaking screen.	895
Do	do	do	do	do	895

[a] Formerly known as Patrick-MacKay.

Government during the fiscal years 1908–1915—Continued.

UNITED STATES COALS—Continued.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.
As received.	Dry coal.				As received.		Dry coal.		Moisture free and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B. t. u.	Calories.	B. t. u.	Calories.	B. t. u.	Calories.		
7	8	9	10	11	12	13	14	15	16	17	18	19
6.73	40.57	48.18	11.25	1.10	11,761	6,534	12,610	7,006	14,206	7,893	23	515
5.68	40.73	49.67	9.60	1.09	12,233	6,796	12,970	7,206	14,347	7,971	18	516
12.83	42.81	43.82	13.37	.70	10,285	5,714	11,799	6,555	13,620	7,567	34	517
12.26	42.31	43.11	14.58	.81	10,221	5,678	11,649	6,472	13,637	7,576	26	518
12.31	43.92	45.92	10.16	.72	10,785	5,992	12,299	6,833	13,690	7,606	27	519
11.88	42.26	43.54	14.20	.64	10,317	5,732	11,708	6,504	13,646	7,581	12	520
12.25	43.85	43.75	12.40	.58	10,489	5,827	11,953	6,641	13,645	7,581	4	521
12.15	42.35	44.59	13.06	.66	10,422	5,790	11,863	6,591	13,645	7,581	10	522
3.77	37.50	46.07	16.43	.31	12,040	6,689	12,512	6,951	14,972	8,318	32	523
4.56	36.73	48.26	15.01	.42	12,239	6,799	12,824	7,124	15,089	8,383	8	524
3.95	37.69	46.70	15.61	.39	12,233	6,796	12,736	7,076	15,092	8,384	9	525
3.59	38.36	47.18	14.46	.37	12,447	6,915	12,910	7,172	15,092	8,384	11	526
3.64	38.24	47.15	14.61	.36	12,297	6,832	12,762	7,090	14,946	8,303	20	527
3.63	38.06	47.34	14.60	.39	12,306	6,837	12,770	7,094	14,953	8,307	53	528
3.25	39.03	46.67	14.30	.41	12,421	6,901	12,838	7,132	14,980	8,322	6	529
4.61	38.73	47.00	14.27	.41	12,316	6,842	12,911	7,173	15,060	8,367	6	530
3.13	37.59	46.25	16.16	.38	12,135	6,742	12,527	6,959	14,942	8,301	9	531
4.28	37.55	47.83	14.62	.41	12,257	6,809	12,805	7,114	14,998	8,332	4	532
2.96	38.52	46.60	14.88	.37	12,379	6,877	12,757	7,087	14,987	8,326	9	533
2.59	40.76	45.35	13.89	.38	12,440	6,911	12,771	7,095	14,831	8,239	8	534
4.83	39.35	49.73	10.92	.41	12,878	7,154	13,532	7,518	15,191	8,439	18	535
2.97	41.07	49.18	9.75	.73	12,978	7,210	13,375	7,431	14,820	8,233	11	536
2.44	39.54	46.68	13.78	1.03	12,617	7,009	12,933	7,185	15,000	8,333	10	537
2.66	40.34	46.59	13.07	.93	12,599	6,999	12,943	7,191	14,889	8,272	16	538
5.02	38.84	48.30	12.86	.87	12,427	6,904	13,084	7,269	15,015	8,342	10	539
4.47	38.39	48.00	13.61	1.07	12,392	6,884	12,972	7,207	15,016	8,342	6	540
2.93	38.82	49.92	11.26	.79	12,860	7,144	13,248	7,360	14,929	8,294	12	541
3.67	39.30	48.73	11.97	.88	12,732	7,073	13,217	7,343	15,014	8,341	3	542
3.32	39.49	46.92	13.59	.62	12,497	6,943	12,926	7,181	14,959	8,311	7	543
5.67	40.13	46.40	13.47	.97	12,212	6,784	12,946	7,192	14,961	8,312	3	544
2.29	38.43	46.84	14.73	1.09	12,498	6,943	12,791	7,106	15,001	8,334	10	545
4.26	37.87	52.17	9.96	.69	12,914	7,174	13,489	7,494	14,981	8,323	12	546
4.60	36.85	51.83	11,32	.65	12,642	7,023	13,252	7,362	14,944	8,302	34	547
5.27	36.49	50.43	13.08	.65	12,341	6,856	13,028	7,238	14,989	8,327	43	548
5.12	37.52	49.16	13.32	.58	12,237	6,798	12,897	7,165	14,879	8,266	19	549
2.57	40.62	50.65	8.73	.56	13,298	7,388	13,649	7,583	14,955	8,308	14	550
3.18	40.00	50.33	9.67	.72	13,076	7,264	13,505	7,503	14,951	8,306	12	551
2.60	36.13	52.48	11.39	.85	13,333	7,407	13,689	7,605	15,449	8,583	12	552
5.56	36.15	51.38	12.47	.88	12,689	7,049	13,436	7,464	15,350	8,528	13	553
2.80	35.41	53.26	11.23	.93	13,264	7,369	13,646	7,581	15,372	8,540	13	554
3.85	36.25	52.05	11.70	.85	13,091	7,273	13,615	7,564	15,419	8,566	4	555

TABLE 2.—*Coals analyzed for the United States*

UNITED STATES COALS—Continued.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
WEST VIRGINIA.					
FAYETTE COUNTY.					
Cannelton	Cannelton			Run of mine	1,974
Dubree and Sun	Rothwell and Sun	Sewell	New River	do	5,150
Do	do	do	do	Nut and slack	2,178
Do	do	do	do	Run of mine	2,455
Do	do	do	do	do	20
Dun Loop, Prudence, and Scarbro.	Dun Loop, Prudence, and Scarbro.	do	do	do	1,007
Elk Ridge	Elk Ridge	Powelton	Kanawha gas	do	1,552
Do	do	do	do	do	197
Elk Ridge, Milburn, and Eagle.	Elk Ridge, Milburn, and St. Clair.	Powelton and No. 5.	Cando gas	do	25,600
Harewood	Harewood	No. 2, gas	No. 2, gas	do	178
Do	do	do	do	do	1,461
Layland and Minden.	Layland and Minden.	Fire Creek and Sewell.	New River	do	1,077
Do	do	do	do	do	5,691
Do	do	do	do	do	105
Do	do	do	do	do	265
Long Branch	Long Branch	No. 2, gas	Long Branch	do	2,339
McDonald and Glen Jean.	McDonald and Collins.	Sewell	New River smokeless.	do	7,017
Milburn	Milburn	Eagle	Milburn gas	do	13,632
Minden	Minden	Sewell	New River	do	193
Prudence	Prudence	do	do	do	2,312
Do	do	do	do	do	4,850
Do	do	do	do	do	1,645
Do	do	do	do	do	369
Do	do	do	do	do	3,020
Do	do	do	do	do	7,804
Red Star	Star	do	do	do	5,700
Do	do	do	do	do	9,300
Do	do	do	do	do	3,214
Do	do	do	do	do	12,198
Do	do	do	do	do	6,400
Do	do	do	do	do	3,011
Smithers	Oakland	Eagle, Nos. 1 and 2.	Richwood	do	1,189
Do	do	do	do	do	1,971
Do	do	do	do	do	216
Do	do	do	do	do	1,793
Do	do	do	do	do	1,641
HARRISON COUNTY.					
Mount Clare	Hutchinson	Pittsburgh		Lump	171
Do	do	do		Nut, pea, and slack	988
Wilsonburg	Miller	do	Fairmont	Lump, over ¾-inch screen.	1,347
KANAWHA COUNTY					
Acme, Decota, and Kayford.	Various mines	No. 2, gas and Coalburg.	Acme splint	Nut, pea, and slack	9,898
Carbondale	No. 112	No. 2, gas	Smithers Creek gas.	Lump, over ¾-inch screen.	2,451
Decota	North Cabin	do	Kanawha, No. 2, gas.	Run of mine	463
Kayford, Leewood, and Wevaco.	Kayford, Thistle, Holly, United, and Raccoon.	No. 2, gas and Coalburg.	Cabin Creek gas	do	19,929
Do	do	do	do	do	1,227
Do	do	do	do	do	21,311

Government during the fiscal years 1908–1915—Continued.

UNITED STATES COALS—Continued.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.
As received.	Dry coal.				As received.		Dry coal.		Moisture free and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B. t. u.	Calories.	B. t. u.	Calories.	B. t. u.	Calories.		
7	8	9	10	11	12	13	14	15	16	17	18	19
4.62	34.12	56.28	9.60	1.40	13,028	7,238	13,659	7,588	15,110	8,394	21	556
2.56	.....	.....	6.32	.....	14,240	7,911	14,614	8,119	15,600	8,667	68	557
2.84	.....	.....	6.90	.....	14,146	7,859	14,559	8,088	15,638	8,688	30	558
2.24	21.35	72.19	6.46	.96	14,293	7,941	14,620	8,122	15,630	8,683	19	559
1.50	21.23	72.07	6.70	1.14	14,317	7,954	14,535	8,075	15,579	8,655	3	560
2.04	18.14	75.70	6.16	.72	14,408	8,004	14,708	8,171	15,673	8,707	18	561
3.18	31.57	61.36	7.07	.95	13,849	7,694	14,304	7,947	15,392	8,551	12	562
3.19	31.21	61.91	6.88	1.01	13,848	7,693	14,304	7,947	15,361	8,534	10	563
2.55	32.49	59.33	8.18	.88	13,702	7,612	14,061	7,812	15,314	8,508	146	564
2.96	34.29	58.72	6.99	1.29	13,811	7,673	14,232	7,907	15,302	8,501	12	565
3.01	33.70	59.29	7.01	1.36	13,845	7,692	14,275	7,931	15,351	8,528	19	566
3.96	20.74	72.93	6.33	.79	14,026	7,792	14,604	8,113	15,591	8,662	12	567
1.32	23.73	70.99	5.28	.92	14,577	8,098	14,772	8,207	15,595	8,664	7	568
4.53	21.30	73.03	5.67	.72	14,034	7,797	14,700	8,167	15,584	8,658	3	569
1.35	20.35	72.87	6.78	.84	14,352	7,973	14,548	8,082	15,606	8,670	6	570
2.88	27.43	65.77	6.80	.87	14,067	7,815	14,484	8,047	15,541	8,634	16	571
3.81	19.90	72.92	7.18	.89	13,902	7,723	14,453	8,029	15,571	8,651	22	572
2.39	32.84	60.74	6.42	.96	14,023	7,791	14,366	7,981	15,352	8,529	33	573
2.64	21.86	72.00	6.14	.91	14,162	7,868	14,546	8,081	15,498	8,610	5	574
1.97	22.84	70.85	6.31	.92	14,351	7,973	14,639	8,133	15,625	8,681	11	575
2.63	24.30	69.03	6.67	.99	14,182	7,879	14,565	8,092	15,606	8,670	23	576
2.31	23.66	68.90	7.44	1.11	14,098	7,832	14,431	8,017	15,591	8,662	14	577
2.27	28.38	69.22	7.40	1.10	14,132	7,851	14,460	8,033	15,616	8,676	10	578
1.28	23.96	69.97	6.07	1.09	14,459	8,033	14,646	8,137	15,592	8,662	16	579
2.23	24.02	69.11	6.87	1.02	14,212	7,896	14,536	8,076	15,608	8,671	31	580
2.02	24.53	69.85	5.62	.78	14,431	8,017	14,729	8,183	15,606	8,670	33	581
1.75	24.88	69.18	5.94	.79	14,404	8,002	14,661	8,145	15,587	8,659	34	582
2.09	24.24	69.74	6.02	.85	14,356	7,976	14,662	8,146	15,601	8,667	17	583
2.05	24.35	70.12	5.53	.86	14,401	8,001	14,702	8,168	15,563	8,646	49	584
2.29	24.16	70.38	5.46	.91	14,391	7,995	14,728	8,182	15,579	8,655	26	585
2.12	23.79	70.27	5.94	.92	14,318	7,954	14,628	8,127	15,552	8,640	17	586
3.66	.....	.....	9.07	.....	13,440	7,467	13,951	7,751	15,343	8,524	12	587
2.46	31.50	59.27	9.23	1.24	13,551	7,528	13,893	7,718	15,306	8,503	23	588
2.95	30.32	60.38	9.30	1.14	13,499	7,499	13,909	7,727	15,335	8,519	13	589
3.28	34.81	56.13	9.06	1.35	13,377	7,432	13,831	7,684	15,209	8,449	20	590
2.40	34.41	56.62	8.97	1.34	13,522	7,512	13,854	7,697	15,219	8,455	19	591
1.68	39.53	53.74	6.73	1.81	13,963	7,757	14,202	7,890	15,227	8,459	4	592
3.51	35.17	52.79	12.04	.76	12,739	7,077	13,202	7,334	15,009	8,338	23	593
2.77	42.02	49.90	8.08	3.46	13,447	7,471	13,830	7,683	15,046	8,359	25	594
3.23	33.12	55.89	10.99	.79	13,064	7,258	13,500	7,500	15,167	8,426	24	595
1.63	36.80	57.41	5.79	1.05	14,206	7,892	14,441	8,023	15,329	8,516	27	596
2.92	34.41	56.91	8.68	1.92	13,526	7,515	13,933	7,741	15,257	8,476	13	597
1.95	34.41	56.35	9.24	1.40	13,576	7,542	13,846	7,692	15,256	8,476	61	598
1.67	35.21	55.96	8.83	1.52	13,689	7,605	13,921	7,734	15,269	8,483	10	599
1.88	33.95	57.03	9.02	1.42	13,603	7,557	13,864	7,702	15,239	8,466	25	600

TABLE 2.—*Coals analyzed for the United States*

UNITED STATES COALS—Continued.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
WEST VIRGINIA—Continued.					
KANAWHA COUNTY—continued.					
Laing and Giles	Berlin and Oakley.	No. 2, gas and Lewiston.	Kanawha gas	Run of mine	1,378
Do	do	do	do	do	162
Laing	Berlin	No. 2, gas	Kanawha, No. 2, gas.	do	23,540
Do	do	do	do	do	947
Queen Shoals	Queen Shoals	No. 5	Queen Shoals	Nut, pea, and slack	4,014
Sharon	Horton	Coalburg	Kanawha	do	7,384
MCDOWELL COUNTY.					
Davy		Sewell ("Davy").	Pocahontas	Run of mine	1,807
Do		do	do	do	1,330
Do		do	do	do	901
Do		do	do	do	4,260
Do		do	do	do	3,230
Do		do	do	do	2,875
Do		do	do	do	1,683
Do		do	do	do	1,444
Elkhorn	Crozer	Pocahontas, No. 3.	do	do	1,186
Hemphill	Oregon	Welch	do	do	1,760
Jed	Jed	Pocahontas, No. 3.	do	do	654
Jed and Leckie	Jed and Leckie	do	do	do	2,540
Landgraf	Empire	do	do	do	1,018
Leckie	Leckie	do	do	do	2,139
Maybeury	Norfolk and Shamokin.	do	do	do	1,181
Do	do	do	do	do	1,069
Do	do	do	do	do	282
Welch	Pocahontas smokeless.	Welch	do	do	18,143
		Pocahontas, No. 3.	do	do	2,408
		do	do	do	2,387
		do	do	do	619
		do	do	do	336
MARION COUNTY.					
	Consolidation	Pittsburgh	Fairmont, gas	Run of mine	8,907
	do	do	do	Lump, over 1½-inch screen.	3,356
MERCER COUNTY.					
McComas	Pinnacle and Crane Creek.	Pocahontas, No. 3.	Pocahontas	Lump, over 1½-inch screen.	2,137
Springton	Spring	do	do	do	545
MINERAL COUNTY.					
Blaine	Blaine	B or Lower Kittanning.	Blaine	Lump, over 1½-inch screen.	
Do	do	do	do	do	1,421
Do	do	do	do	do	1,980
Keyser	New Creek	do	Peerless	Slack	1,260
MINGO COUNTY.					
Chattaroy	Buffalo	Winifrede	Buffalo white ash	Nut, pea, and slack	6,036

Government during the fiscal years 1908–1915—Continued.

UNITED STATES COALS—Continued.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.
As received.	Dry coal.				As received.		Dry coal.		Moisture free and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B. t. u.	Calories.	B. t. u.	Calories.	B. t. u.	Calories.		
7	8	9	10	11	12	13	14	15	16	17	18	19
2.84	33.18	59.45	7.37	1.71	13,858	7,699	14,263	7,924	15,398	8,554	16	601
3.14	33.88	57.16	8.96	2.44	13,422	7,457	13,857	7,698	15,221	8,456	4	602
2.71	35.21	56.12	8.67	1.68	13,574	7,541	13,952	7,751	15,276	8,487	96	603
2.39	36.03	55.70	8.27	1.57	13,653	7,585	13,987	7,771	15,248	8,471	15	604
3.53	33.61	55.44	10.95	1.27	13,000	7,222	13,476	7,487	15,133	8,407	31	605
4.27	34.35	53.61	12.04	1.08	12,611	7,006	13,174	7,319	14,977	8,321	30	606
3.64	19.37	73.23	7.40	.73	13,943	7,746	14,470	8,039	15,626	8,681	64	607
3.62	19.52	73.24	7.24	.67	13,948	7,749	14,472	8,040	15,602	8,668	11	608
3.61	19.66	73.36	6.98	.68	14,028	7,793	14,553	8,085	15,645	8,692	35	609
2.10	18.35	74.57	7.08	.62	14,239	7,911	14,544	8,080	15,652	8,696	10	610
1.74	19.07	74.57	6.36	.59	14,459	8,033	14,715	8,175	15,714	8,730	17	611
2.17	19.27	75.56	5.17	.63	14,580	8,100	14,903	8,279	15,715	8,731	47	612
4.01	18.66	74.32	7.02	.59	13,957	7,754	14,540	8,078	15,638	8,688	10	613
2.99	17.65	75.97	6.38	.64	14,192	7,884	14,629	8,127	15,626	8,681	14	614
1.91	19.15	74.67	6.18	.72	14,463	8,035	14,745	8,192	15,716	8,731	9	615
2.36	19.01	73.44	7.55	.83	14,136	7,853	14,478	8,043	15,660	8,700	23	616
5.12	19.16	74.00	6.84	.91	13,702	7,612	14,441	8,023	15,501	8,612	33	617
3.26	17.89	76.51	5.60	.78	14,348	7,971	14,831	8,239	15,711	8,728	26	618
2.87	17.74	75.48	6.78	.65	14,251	7,917	14,672	8,151	15,739	8,744	17	619
3.28	19.29	74.10	6.61	.68	14,172	7,873	14,653	8,141	15,690	8,717	18	620
4.39	18.83	73.93	7.24	1.03	13,912	7,729	14,551	8,084	15,687	8,715	82	621
2.66	19.81	73.21	6.98	.84	14,176	7,876	14,563	8,091	15,656	8,698	38	622
2.63	19.70	72.63	7.67	1.33	13,976	7,764	14,353	7,974	15,545	8,636	3	623
2.27	18.37	73.24	8.39	.83	13,987	7,771	14,312	7,951	15,623	8,679	176	624
2.86	19.87	74.41	5.72	.68	14,356	7,976	14,779	8,211	15,676	8,709	46	625
2.62	18.23	75.34	6.43	.63	14,278	7,932	14,662	8,146	15,670	8,706	24	626
2.44	17.93	75.89	6.18	.62	14,320	7,956	14,678	8,154	15,645	8,692	16	627
2.06	18.02	74.98	7.00	.66	14,258	7,921	14,558	8,088	15,654	8,697	5	628
2.37	37.06	54.67	8.27	1.35	13,547	7,526	13,876	7,709	15,127	8,404	19	629
1.95	37.31	55.87	6.82	.87	13,816	7,676	14,091	7,828	15,122	8,401	11	630
2.39	18.38	74.80	6.82	.66	14,292	7,940	14,642	8,134	15,714	8,730	22	6 1
3.45	17.71	75.03	7.26	.92	14,048	7,804	14,550	8,083	15,689	8,716	8	632
3.17	15.92	74.63	9.45	1.81	13,748	7,638	14,198	7,888	15,680	8,711	33	633
2.34	14.93	72.26	12.81	1.73	13,256	7,364	13,574	7,541	15,568	8,649	23	634
2.09	15.72	68.18	16.10	1.81	12,676	7,042	12,947	7,193	15,431	8,573	16	635
2.71	16.85	68.89	14.26	2.21	12,918	7,177	13,278	7,377	15,486	8,603	24	636
4.75	34.37	52.31	13.32	.99	12,315	6,842	12,929	7,183	14,916	8,287	39	637

TABLE 2.—*Coals analyzed for the United States*

UNITED STATES COALS—Continued.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
WEST VIRGINIA—Continued.					
RALEIGH COUNTY.					
Glen White	Glen White	Beckley	New River	Run of mine	1,600
Do	do	do	do	do	4,646
Do		do	do	do	4,025
		do	do	do	10,599
Glen White (near)	Glen White and Affinity.	do	do	do	4,450
Do	Glen White and Stotesbury.	do	do	do	9,392
Do	Glen White, Gulf, Stotesbury, Pemberton, and Big Stick.	do	do	do	20,050
Sprague	Cranberry	Sewell	do	Crushed to pass through 2-inch screen.	20,809
Do	do	do	do	do	28,408
Stanaford	Piney	Sewell and Beckley.	do	Run of mine	2,061
Do	do	do	do	do	7,093
Do	do	do	do	do	2,001
Do	do	do	do	do	1,560
Do	do	do	do	do	2,270
Do	do	do	do	do	315
	(Various mines)		do	do	1,375
RANDOLPH COUNTY.					
Weaver	Weaver	Lower Kittanning.	Beaver Creek	Run of mine	2,876
TUCKER COUNTY.					
Albert	Douglas	Lower Kittanning.	Douglas	Run of mine	904
Coketon	Davis	Upper Kittanning.	Davis	do	1,472
Thomas	Thomas mines	Freeport and Lower Kittanning.	Thomas	do	79,246
Do	No. 34 and Nos. 36 to 41.	Lower Kittanning.	Davis	do	15,280
Do	do	do	do	do	924
Do	No. 37	do	do	do	1,645
Do	do	do	do	do	2,579
RALEIGH AND FAYETTE COUNTIES.					
	(Various mines)		New River	Run of mine	10,712
	do	Sewell	do	do	379
	do	do	do	do	7,447
	do	do	do	do	1,577
	do	do	do	do	1,923
	do	Sewell and Beckley.	do	do	1,660
	do	Sewell	do	do	410
	do		do	do	1,684
	do	Sewell	do	do	1,426
	do	Sewell and Beckley.	do	do	9,887
	do	Sewell	do	do	1,082
	do	Sewell and Beckley.	do	do	9,372

Government during the fiscal years 1908–1915—Continued.

UNITED STATES COALS—Continued.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.
As received.	Dry coal.				As received.		Dry coal.		Moisture free and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B. t. u.	Calories.	B. t. u.	Calories.	B. t. u.	Calories.		
7	8	9	10	11	12	13	14	15	16	17	18	19
3.96	19.53	74.08	6.39	0.97	14,050	7,806	14,629	8,127	15,628	8,682	26	638
3.26	18.17	74.08	7.75	.63	13,967	7,759	14,438	8,021	15,651	8,695	36	639
3.00	18.01	74.98	7.01	.69	14,078	7,821	14,513	8,063	15,607	8,671	15	640
3.04	18.06	75.78	6.14	.84	14,241	7,912	14,688	8,160	15,649	8,694	46	641
3.07	17.55	75.34	7.11	.75	14,118	7,843	14,565	8,092	15,680	8,711	41	642
3.04	18.43	75.76	5.81	.69	14,258	7,921	14,705	8,169	15,612	8,673	47	643
2.46	18.46	74.75	6.79	.68	14,160	7,867	14,517	8,065	15,575	8,653	117	644
2.98	21.32	74.38	4.30	.73	14,585	8,103	15,033	8,352	15,708	8,727	51	645
2.55	22.26	72.72	5.02	.82	14,504	8,058	14,884	8,269	15,671	8,706	119	646
2.50	21.11	73.54	5.35	.76	14,532	8,073	14,905	8,281	15,747	8,749	20	647
2.68	20.17	73.52	6.34	.95	14,264	7,924	14,657	8,143	15,649	8,694	70	648
2.69	.....	.....	6.22	.....	14,302	7,946	14,697	8,165	15,672	8,707	44	649
2.50	19.94	73.50	6.53	.96	14,291	7,939	14,657	8,143	15,681	8,712	41	650
2.43	.....	.....	6.67	.....	14,269	7,927	14,624	8,124	15,669	8,705	23	651
2.09	21.61	72.45	5.94	.79	14,416	8,009	14,724	8,180	15,654	8,697	7	652
2.73	20.32	73.53	6.15	.68	14,255	7,919	14,655	8,142	15,615	8,675	21	653
1.81	28.77	58.72	12.51	1.20	13,030	7,239	13,270	7,372	15,167	8,426	13	654
2.87	.....	.....	7.51	.....	14,024	7,791	14,438	8,021	15,610	8,672	17	655
3.86	21.47	70.01	8.52	1.08	13,688	7,604	14,238	7,910	15,564	8,647	20	656
3.37	17.39	72.47	10.14	1.02	13,446	7,470	13,915	7,731	15,485	8,603	673	657
3.57	.....	.....	9.18	.....	13,666	7,592	14,172	7,873	15,604	8,669	90	658
4.09	23.70	67.06	9.24	1.18	13,543	7,524	14,121	7,845	15,559	8,644	27	659
3.18	22.07	70.06	7.87	1.04	13,925	7,736	14,382	7,990	15,611	8,673	60	660
2.77	24.29	66.52	9.19	1.10	13,747	7,637	14,139	7,855	15,570	8,650	67	661
2.92	22.09	72.48	5.43	.70	14,390	7,994	14,823	8,235	15,674	8,708	51	662
2.72	20.96	73.43	5.61	.89	14,381	7,989	14,783	8,213	15,662	8,701	16	663
2.77	21.44	72.68	5.88	.90	14,347	7,971	14,756	8,198	15,678	8,710	106	664
3.10	21.18	72.98	5.84	.84	14,285	7,936	14,742	8,190	15,656	8,698	37	665
2.80	20.55	72.93	6.52	.87	14,197	7,887	14,606	8,114	15,625	8,681	83	666
2.76	21.52	72.47	6.01	.76	14,291	7,939	14,697	8,165	15,637	8,687	32	667
3.19	20.64	73.60	5.76	.90	14,317	7,954	14,789	8,216	15,693	8,718	13	668
2.27	20.81	72.79	6.40	.89	14,301	7,945	14,633	8,129	15,634	8,686	27	669
3.16	21.74	71.69	6.57	.85	14,118	7,843	14,579	8,099	15,604	8,669	56	670
2.35	22.61	71.56	5.83	.82	14,357	7,976	14,703	8,168	15,613	8,674	36	671
2.99	21.13	72.39	6.48	.87	14,157	7,865	14,593	8,107	15,604	8,669	41	672
3.49	21.07	72.49	6.44	.90	14,097	7,832	14,607	8,115	15,612	8,673	40	673

TABLE 2.—*Coals analyzed for the United States*

UNITED STATES COALS—Continued.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
WEST VIRGINIA—Continued.					
RALEIGH AND FAYETTE COUNTIES—continued.					
.....	(Various mines)..	Sewell, Beckley, and Fire Creek.	New River	Run of mine.....	1,162
.....	....do.....	Sewell.....	....do.....	Nut and slack.....	2,000
.....	....do.....	....do.....	....do.....	Run of mine.....	1,439
.....	....do.....	....do.....	....do.....	....do.....	2,816
.....	....do.....	....do.....	....do.....	....do.....	3,859
.....	....do.....	....do.....	....do.....	....do.....	1,767
.....	....do.....	....do.....	....do.....	....do.....	1,800
.....	....do.....	Sewell and Fire Creek.	....do.....	....do.....	2,018
.....	....do.....	Sewell.....	....do.....	....do.....	30,624
.....	....do.....		....do.....	....do.....	115,871
.....	....do.....		....do.....	....do.....	115,439
.....	....do.....		....do.....	....do.....	89,431
.....	....do.....		....do.....	....do.....	190,975
.....	....do.....		....do.....	....do.....	50,113
.....	....do.....		....do.....	....do.....	84,990
.....	....do.....		....do.....	....do.....	87,333
WEST VIRGINIA AND VIRGINIA.					
M'DOWELL, MERCER, AND TAZEWELL COUNTIES.					
.....	(Various mines)...	Pocahontas, No. 3.	Pocahontas.....	Run of mine.....	1,306
.....	....do.....	....do.....	....do.....	....do.....	2,410
.....	....do.....	....do.....	....do.....	....do.....	2,107
.....	....do.....	....do.....	....do.....	....do.....	16,153
.....	....do.....	....do.....	....do.....	....do.....	2,497
.....	....do.....	....do.....	....do.....	....do.....	1,585
.....	....do.....	....do.....	....do.....	....do.....	3,270
.....	....do.....	Pocahontas, No. 3, and Sewell.	....do.....	....do.....	20,264
.....	....do.....	....do.....	....do.....	....do.....	2,251
.....	....do.....	....do.....	....do.....	Screenings.....	7,204
.....	....do.....	Pocahontas, No. 3.	....do.....	Run of mine.....	2,236
.....	....do.....	....do.....	....do.....	....do.....	1,078
.....	....do.....	....do.....	....do.....	....do.....	10,080
.....	....do.....	....do.....	....do.....	....do.....	181,494
.....	....do.....	....do.....	....do.....	....do.....	407,376
.....	....do.....	....do.....	....do.....	....do.....	38,915
.....	....do.....	....do.....	....do.....	....do.....	66,360
.....	....do.....	....do.....	....do.....	....do.....	223,966
.....	....do.....	....do.....	....do.....	....do.....	266,721
.....	....do.....	....do.....	....do.....	....do.....	328,987
.....	....do.....	....do.....	....do.....	....do.....	322,756
.....	....do.....	....do.....	....do.....	....do.....	169,729
.....	....do.....	Pocahontas, Nos. 3 and 4, and Sewell.	....do.....	....do.....	335,402

Government during the fiscal years 1908–1915—Continued.

UNITED STATES COALS—Continued.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.
As received.	Dry coal.				As received.		Dry coal.		Moisture free and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B. t. u.	Calories.	B. t. u.	Calories.	B. t. u.	Calories.		
7	8	9	10	11	12	13	14	15	16	17	18	19
2.09	19.50	74.18	6.32	0.65	14,353	7,974	14,659	8,144	15,648	8,693	13	674
2.78	23.06	70.81	6.13	.93	14,246	7,914	14,653	8,141	15,610	8,672	16	675
2.24	22.10	71.79	6.11	1.00	14,362	7,973	14,691	8,162	15,647	8,693	8	676
1.93	22.75	71.36	5.89	.90	14,433	8,018	14,717	8,176	15,638	8,688	10	677
1.21	22.48	71.74	5.78	.95	14,543	8,079	14,721	8,178	15,624	8,680	16	678
2.43	22.33	71.56	6.11	.92	14,280	7,933	14,636	8,131	15,588	8,660	8	679
3.33	23.56	70.03	6.41	.76	14,049	7,805	14,533	8,074	15,528	8,627	9	680
2.08	22.32	71.36	6.32	.86	14,294	7,941	14,598	8,110	15,583	8,657	40	689
2.46	22.04	73.22	4.74	.84	14,529	8,072	14,895	8,275	15,636	8,687	135	682
2.77	.....	.....	4.84	.....	14,570	8,094	14,985	8,325	15,747	8,748	60	683
3.10	16.63	78.82	4.55	.58	14,532	8,073	14,997	8,332	15,712	8,729	236	684
2.70	16.61	78.32	5.07	.66	14,517	8,065	14,920	8,289	15,717	8,732	205	685
2.73	20.79	73.96	5.25	.84	14,458	8,032	14,864	8,258	15,688	8,716	342	686
2.55	20.95	73.16	5.89	.81	14,377	7,987	14,753	8,196	15,676	8,709	46	687
2.69	19.80	74.66	5.54	.92	14,405	8,003	14,803	8,224	15,671	8,706	72	688
2.25	19.57	74.09	6.34	.84	14,344	7,969	14,674	8,152	15,667	8,704	95	689
2.62	20.53	74.35	5.12	.88	14,478	8,043	14,868	8,260	15,670	8,706	24	690
2.66	19.45	75.06	5.49	.71	14,472	8,040	14,867	8,259	15,731	8,739	49	691
2.86	20.75	73.34	5.91	.67	14,378	7,988	14,801	8,223	15,731	8,739	46	692
1.92	21.36	72.07	6.57	.56	14,401	8,001	14,683	8,157	15,716	8,731	86	693
2.96	20.67	72.73	6.60	.64	14,253	7,918	14,688	8,160	15,726	8,737	18	694
2.99	20.45	73.93	5.62	.64	14,395	7,997	14,839	8,244	15,723	8,735	33	695
2.41	20.53	73.74	5.73	.54	14,444	8,024	14,801	8,223	15,701	8,723	33	696
1.93	18.75	75.18	6.07	.85	14,440	8,022	14,724	8,180	15,676	8,709	81	697
2.48	18.69	75.39	5.92	.82	14,393	7,996	14,759	8,199	15,688	8,716	20	698
4.23	18.24	73.73	8.03	.70	13,728	7,627	14,334	7,963	15,586	8,659	23	699
2.81	19.67	74.35	5.98	.57	14,312	7,951	14,726	8,181	15,663	8,702	21	700
3.79	20.58	73.82	5.60	.68	14,251	7,917	14,812	8,229	15,691	8,717	17	701
1.13	20.09	74.04	5.87	.66	14,599	8,111	14,766	8,203	15,687	8,715	23	702
2.51	.....	.....	5.97	.....	14,524	8,069	14,898	8,277	15,844	8,802	45	703
2.63	18.74	75.87	5.39	.66	14,529	8,072	14,921	8,289	15,771	8,762	986	704
3.10	16.70	76.72	6.58	.74	14,234	7,908	14,689	8,161	15,724	8,736	89	705
2.71	17.01	76.15	6.84	.55	14,275	7,931	14,673	8,152	15,750	8,750	164	706
2.52	16.48	76.70	6.82	.60	14,329	7,961	14,699	8,166	15,775	8,764	546	707
2.75	17.88	75.98	6.14	.65	14,389	7,994	14,796	8,220	15,764	8,758	443	708
2.58	18.57	74.96	6.47	.62	14,345	7,969	14,725	8,181	15,744	8,747	293	709
2.27	19.91	73.66	6.43	.59	14,384	7,991	14,718	8,177	15,729	8,738	297	710
2.59	19.74	73.85	6.41	.57	14,313	7,952	14,694	8,163	15,700	8,722	157	711
1.92	17.95	75.98	6.07	.75	14,456	8,031	14,739	8,188	15,691	8,717	337	712

TABLE 2.—*Coals analyzed for the United States*

UNITED STATES COALS—Continued.

Where mined.			Commercial name of coal.	Size of coal.	Tons delivered.
State, county, and town.	Mine.	Bed.			
1	2	3	4	5	6
WYOMING.					
HOT SPRINGS COUNTY.					
Gebo	Owl Creek	Gebo	Owl Creek	Lump	1,727
LINCOLN COUNTY.					
Sublet	No. 5	Willow Creek	Kemmerer	Run of mine	1,002
SHERIDAN COUNTY.					
Acme	Acme	Monarch	Acme	do	1,803
Carneyville	Carney	Carney	Carney	Lump	1,175
Do	do	do	do	do	386
Do	do	do	do	do	2,043
Do	do	do	do	do	966
Do	do	do	do	Lump, over 2½-inch and through 4-inch screens.	1,055
Do	do	do	do	Lump, over 5-inch bar screen.	1,742
Do	do	do	do	Lump, over 5-inch shaking screen.	3,166
Do	do	do	do	do	1,630
Do	do	do	do	do	3,450
Do	do	do	do	do	474
Do	do	do	do	do	2,773
Do	do	do	do	Run of mine	1,788
Do	Model	do		Lump, over 1¼-inch screen.	201
Dietz	Sheridan	Sheridan, No. 2	Sheridan	Run of mine	867
Do	No. 7	do	do	do	3,873
Kooi	Kooi	Monarch	Kooi	Lump	444
Monarch	No. 1	do	Monarch	Run of mine	1,548
SWEETWATER COUNTY.					
Rock Springs	Blairtown	No. 1	Star lump	Lump, over 3-inch screen.	3,260
Do	do	do	do	do	1,783

Government during the fiscal years 1908–1915—Continued.

UNITED STATES COALS—Continued.

Proximate analysis.					Calorific value, per pound.						Number of analyses averaged.	Index number.
As received.	Dry coal.				As received.		Dry coal.		Moisture free and ash free.			
Moisture, per cent.	Volatile matter, per cent.	Fixed carbon, per cent.	Ash, per cent.	Sulphur, per cent.	B. t. u.	Calories.	B. t. u.	Calories.	B. t. u.	Calories.		
7	8	9	10	11	12	13	14	15	16	17	18	19
14.71	44.19	51.14	4.67	0.62	11,157	6,198	13,081	7,267	13,722	7,623	7	713
2.73	38.19	56.29	5.52	.94	13,418	7,454	13,795	7,664	14,601	8,112	9	714
23.15	47.91	46.74	5.35	.68	9,559	5,311	12,438	6,910	13,141	7,301	36	715
21.56	43.10	52.36	4.54	.52	9,710	5,394	12,379	6,877	12,968	7,204	24	716
21.02	44.86	50.67	4.47	.54	9,697	5,387	12,278	6,821	12,853	7,141	13	717
22.50	42.38	52.41	5.21	.65	9,544	5,302	12,315	6,842	12,992	7,218	61	718
21.80	44.73	50.51	4.76	.49	9,678	5,377	12,376	6,876	12,995	7,219	9	719
22.23	48.43	46.30	5.27	.55	9,579	5,322	12,317	6,843	13,002	7,223	3	720
21.93	45.67	49.40	4.93	.43	9,644	5,358	12,353	6,863	12,994	7,219	9	721
22.54	45.92	49.26	4.82	.54	9,669	5,372	12,483	6,935	13,115	7,286	22	722
22.66	44.93	49.89	5.18	.65	9,577	5,321	12,383	6,879	13,059	7,255	17	723
22.45	43.80	52.11	4.09	.47	9,697	5,387	12,504	6,947	13,037	7,243	15	724
19.69	45.10	50.70	4.20	.54	10,066	5,592	12,534	6,963	13,084	7,269	9	725
22.49	45.14	50.30	4.56	.47	9,604	5,336	12,391	6,884	12,983	7,213	14	726
22.59	43.76	45.15	11.09	.63	8,912	4,951	11,513	6,396	12,949	7,194	25	727
22.74	44.14	50.90	4.96	.39	9,542	5,301	12,350	6,861	12,995	7,219	5	728
19.33	40.45	45.36	14.19	1.32	9,095	5,053	11,274	6,263	13,138	7,299	18	729
23.53	44.42	44.33	11.25	.81	8,760	4,867	11,456	6,364	12,908	7,171	33	730
22.20	52.52	41.88	5.60	.53	9,602	5,334	12,342	6,857	13,074	7,263	5	731
22.05	44.20	48.17	7.63	.76	9,506	5,281	12,195	6,775	13,202	7,334	34	732
7.90	43.56	52.55	3.89	.85	12,471	6,928	13,541	7,523	14,089	7,827	17	733
7.35	42.08	52.07	5.85	.93	12,251	6,806	13,223	7,346	14,045	7,803	6	734

ESSENTIAL DATA IN REGARD TO COAL CONTRACTS.

In the following pages are given the essential data in regard to the place, date of delivery, purchaser, price, and contract guaranties for the coals that were sampled and analyzed as shown in Table 2. The numbers refer to the index numbers in Table 2 (column 19). Prices given are per ton of 2,240 pounds, delivered, except where otherwise stated. The year given as date of delivery is the fiscal year—for example, 1910–11 refers to the fiscal year beginning July 1, 1910, and ending June 30, 1911.

AUSTRALIA COALS.

1. Bituminous coal delivered to Fort Rosecrans, Cal., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 2.5 per cent moisture, "as received"; 5 per cent ash, and 14,000 B. t. u., "dry coal." Price, $8.85 per ton for delivery at San Diego, Cal.

2. Bituminous coal delivered to Fort Davis, Alaska, Quartermaster Corps, War Department, 1914–15. Contract guaranties: 3 per cent moisture, "as received"; 40 per cent volatile matter, 1 per cent sulphur, 5 per cent ash, and 14,000 B. t. u., "dry coal." Price, $20.25 per ton.

3. Bituminous coal delivered to the United States military prison, Alcatraz, Cal., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 5 per cent ash, "dry coal"; 14,800 B. t. u., "as received." Price, $9.15 per ton.

4. Bituminous coal delivered to Fort Baker, Cal., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 5 per cent ash, "dry coal"; 14,800 B. t. u., "as received." Price, $9.40 per ton.

5. Bituminous coal delivered to Fort McDowell, Cal., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 5 per cent ash, "dry coal"; 14,800 B. t. u., "as received." Price, $9.15 per ton.

6. Bituminous coal delivered to Presidio of Monterey, Cal., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 5 per cent ash, "dry coal"; 14,800 B. t. u., "as received." Price, $12.60 per ton.

7. Bituminous coal delivered to Fort Miley, Cal., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 2.5 per cent moisture, "as received"; 43.6 per cent volatile matter, 0.8 per cent sulphur, 6 per cent ash, 13,600 B. t. u., "dry coal." Price, $10.50 per ton.

8. Bituminous coal delivered to Letterman General Hospital, Presidio of San Francisco, Cal., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 2.5 per cent moisture, "as received"; 40 per cent volatile matter, 1 per cent sulphur, 6 per cent ash, 13,600 B. t. u., "dry coal." Price, $10 per ton.

9. Bituminous coal delivered to Presidio of Monterey, Cal., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 2.5 per cent moisture, "as received"; 6 per cent ash, 13,600 B. t. u., "dry coal." Price, $13.57 per ton.

10. Bituminous coal delivered to Presidio of San Francisco and Fort Mason, Cal., Quartermaster Corps, War Department, 1913–14. Contract guaranties:

2.5 per cent moisture, "as received"; 40 per cent volatile matter, 8 per cent sulphur and 6 per cent ash, 13,600 B. t. u., "dry coal." Price, $10 per ton at presidio and $9.75 per ton at the fort.

11. Bituminous coal delivered to Fort Baker, Cal., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 2.5 per cent moisture, "as received"; 6 per cent ash, 13,600 B. t. u., "dry coal." Price, $10.65 per ton.

12. Bituminous coal delivered to forts of San Francisco Harbor, Cal., Quartermaster Corps, War Department, 1913–14. Contract guaranties same as No. 11. Price, $10.50 per ton.

13. Bituminous coal delivered to Fort Winfield Scott, Cal. (vessels), Quartermaster Corps, War Department, 1913–14. Contract guaranties: 2.5 per cent moisture, "as received"; 6 per cent ash, 13,600 B. t. u., "dry coal." Price, $8.50 per ton.

14. Bituminous coal delivered to Presidio of San Francisco, Cal., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 5.04 per cent ash, "dry coal"; 14,020 B. t. u., "as received." Price, $9.40 per ton.

15. Bituminous coal delivered to Fort Miley, Cal., Quartermaster Corps, War Department, 1911–12. Contract guaranties same as No. 14. Price, $9.90 per ton.

16. Bituminous coal delivered to Fort Mason, Cal., Quartermaster Corps, War Department, 1911–12. Contract guaranties same as No. 14. Price, $9.15 per ton.

17. Bituminous coal delivered to Benicia Arsenal, Cal., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 4.12 per cent ash, "dry coal"; 14,474 B. t. u., "as received." Price, $9.84 per ton.

18. Bituminous coal delivered to Fort Barry, Cal., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 5.04 per cent ash, "dry coal"; 14,020 B. t. u., "as received." Price, $10.90 per ton.

19. Bituminous coal delivered to Schofield Barracks, Hawaii Territory, Quartermaster Corps, War Department, 1911–12. Contract guaranties: 7.13 per cent ash, "dry coal"; 13,607 B. t. u., "as received." Price, $9.25 per ton.

20. Bituminous coal delivered to Fort Ruger, Hawaii Territory, Quartermaster Corps, War Department, 1911–12. Contract guaranties same as No. 19. Price, $10.75 per ton.

CANADA COALS.

21. Bituminous coal delivered to Fort George Wright, Wash., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 6.5 per cent moisture, "as received"; 16 per cent volatile matter, 0.35 per cent sulphur, 10 per cent ash, 14,200 B. t. u., "dry coal." Price, $6.214 per ton.

22. Bituminous coal delivered to Fort George Wright, Wash., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 1 per cent moisture, "as received"; 20 to 23 per cent volatile matter, 0.4 per cent sulphur, 12 per cent ash, and 13,500 B. t. u., "dry coal." Price, $3.36 per ton f. o. b. mines.

23. Bituminous coal delivered to San Francisco Harbor, Cal., Quartermaster Corps, War Department, 1911–12.

24. Bituminous coal delivered to the depot quartermaster, United States Army, Seattle, Wash., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 1.38 per cent moisture, "as received"; 29.34 per cent volatile matter, 1.01 per cent sulphur, 14.47 per cent ash, and 12,500 B. t. u., "dry coal." Price, $3.40 per ton in vessels at West Seattle, Wash.

25. Bituminous coal delivered to Fort Miley, Cal., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 6.61 per cent ash, "dry coal"; 13,906 B. t. u., "as received." Price, $9.50 per ton.

26. Bituminous coal delivered to Fort Barry, Cal., Quartermaster Corps, War Department, 1911–12. Contract guaranties same as No. 25. Price, $10.50 per ton.

27. Bituminous coal delivered to Presidio of San Francisco, Cal., Quartermaster Corps, War Department, 1911–12. Contract guaranties same as No. 25.

28. Bituminous coal delivered to Fort St. Michael, Alaska, Quartermaster Corps, War Department, 1912–13. Contract guaranties: 2.44 per cent moisture, "as received"; 11.65 per cent ash; 14,000 B. t. u., "dry coal." Price, $20.50 per ton.

29. Bituminous coal delivered to Fort Davis, Alaska, Quartermaster Corps, War Department, 1912–13. Price, $20.50 per ton.

30. Bituminous coal delivered to Fort Ward, Wash., Quartermaster Corps, War Department, 1912–13. Price, $9.75 per ton.

31. Bituminous coal delivered to Fort Worden, Wash., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 1.75 per cent moisture, "as received"; 10 per cent ash; 13,600 B. t. u., "dry coal." Price, $9.50 per ton.

32. Bituminous coal delivered to Fort Barry, Cal., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 2.5 per cent moisture, "as received"; 13 per cent ash; 12,510 B. t. u., "dry coal." Price, $11.50 per ton.

33. Bituminous coal delivered to Letterman General Hospital, San Francisco, Cal., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 2.5 per cent moisture, "as received"; 13 per cent ash; 12,510 B. t. u., "dry coal." Price, $9 per ton.

34. Bituminous coal delivered to Fort McDowell, Cal., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 2.5 per cent moisture, "as received"; 13 per cent ash; 12,510 B. t. u., "dry coal." Price, $8.90 per ton.

35. Bituminous coal delivered to Fort McDowell, Cal., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 2.5 per cent moisture, "as received"; 40 per cent volatile matter, 1.75 per cent sulphur, 10 per cent ash, and 12,800 B. t. u., "dry coal." Price, $9 per ton for delivery at San Francisco, Cal.

36. Bituminous coal delivered to Fort Winfield Scott, Cal., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 2.5 per cent moisture, "as received"; 40 per cent volatile matter, 1.75 per cent sulphur, 10 per cent ash, and 12,800 B. t. u., "dry coal." Price, $9 per ton.

37. Bituminous coal delivered to the United States military prison, Alcatraz, Cal., Quartermaster Corps, War Department, 1914–15. Contract guaranties same as No. 36. Price, $8.85 per ton.

38. Bituminous coal delivered to Fort Baker, Cal., Quartermaster Corps, War Department, 1914–15. Contract guaranties same as No. 36. Price, $9.65 per ton.

39. Bituminous coal delivered to Fort McDowell, Cal., Quartermaster Corps, War Department, 1914–15. Contract guaranties same as No. 36. Price, $8.50 per ton for delivery at San Francisco, Cal.

40. Bituminous coal delivered to Fort Davis, Alaska, Quartermaster Corps, War Department, 1911–12. Contract guaranties: 7.6 per cent ash, "dry coal"; 13,360 B. t. u., "as received." Price, $19.49 per ton.

41. Bituminous coal delivered to Fort Casey, Wash., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 1.75 per cent moisture, "as received"; 9.46 per cent ash, 13,600 B. t. u., "dry coal." Price, $9.75 per ton.

42. Bituminous coal delivered to Fort Flagler, Wash., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 1.75 per cent moisture, "as received"; 9.46 per cent ash, 13,600 B. t. u., "dry coal." Price, $9.75 per ton.

43. Bituminous coal delivered to Fort Worden, Wash., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 1.82 per cent moisture, "as received"; 8.49 per cent ash, and 13,000 B. t. u., "dry coal." Price, $8.05 per ton.

ALABAMA COALS.

44. Bituminous coal delivered to Fort Barrancas, Fla., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 1 per cent moisture, "as received"; 7 per cent ash, "dry coal"; 14,200 B. t. u., "dry coal." Price, $5.60 per ton.

45. Bituminous coal delivered to Fort Pickens, Fla., Quartermaster Corps, War Department, 1912–13. Contract guaranties same as No. 44. Price, $6.55 per ton.

46. Bituminous coal delivered to Forts Barrancas and Pickens, Fla., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 8 per cent moisture, "as received"; 8 per cent ash, 14,000 B. t. u., "dry coal." Prices, Fort Barrancas, $5.85 per ton; Fort Pickens, $6.80 per ton.

47. Bituminous coal delivered to Fort Morgan, Ala., Quartermaster Corps, War Department, 1914–15. Price, $5.75 per ton.

48. Bituminous coal delivered to Forts Barrancas and Pickens, Fla., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 8 per cent moisture, "as received"; 37 per cent volatile matter, 1 per cent sulphur, 7 per cent ash, and 14,000 B. t. u., "dry coal." Price, $5.65 per ton for delivery at Fort Barrancas and $5.50 per ton for delivery at Fort Pickens.

49. Bituminous coal delivered to Fort Morgan, Ala., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 5 per cent moisture, "as received"; 10 per cent ash, 13,500 B. t. u., "dry coal." Price, $3.30 per ton delivered at Mobile.

50. Bituminous coal delivered to Fort Morgan, Ala. (for vessels), Quartermaster Corps, War Department, 1911–12. Contract guaranties: 8 per cent ash, "dry coal"; 13,500 B. t. u., "as received." Price, $3.30 per ton delivered at Mobile, Ala.

51. Bituminous coal delivered to eighth lighthouse district, Mobile, Ala., Bureau of Lighthouses, Department of Commerce, 1911–12. Contract guaranties: 11 per cent ash, "dry coal"; 13,050 B. t. u., "as received." Price, $3.34 per ton.

52. Bituminous coal delivered to the customhouse, New Orleans, La., Treasury Department, 1914–15. Contract guaranties: 37 per cent volatile matter, 2.5 per cent sulphur, 10 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3.30 per ton.

53. Bituminous coal delivered to the navy yard at Pensacola, Fla., Navy Department, in June, 1914.

54. Bituminous coal delivered to the navy yard at Pensacola, Fla., Navy Department, in May and June, 1914.

55. Bituminous coal delivered to the United States engineer office, Montgomery, Ala., War Department, 1914–15. Contract guaranties: 2 per cent moisture, "as received"; 29.91 per cent volatile matter, 1.33 per cent sulphur, 5.45 per cent ash, and 14,750 B. t. u., "dry coal." Price, $1.75 per ton of 2,000 pounds.

56. Bituminous coal delivered to the navy yard at Pensacola, Fla., Navy Department, in June, 1914.

57. Bituminous coal delivered to the customhouse, New Orleans, La., Treasury Department, 1911–12. Contract guaranties: 8 per cent ash, "dry coal"; 13,900 B. t. u., "as received." Price, $3.20 per ton.

58. Bituminous coal delivered to the customhouse, New Orleans, La., Treasury Department, 1908–9. Contract guaranties: 6 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3.25 per ton.

59. Bituminous coal delivered to the mint building, New Orleans, La., Treasury Department, 1908–9. Contract guaranties: 6 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3.40 per ton.

60. Bituminous coal delivered to the United States engineer office, Mobile, Ala., War Department, 1914–15. Contract guaranties: 1.6 per cent moisture, "as received"; 28 per cent volatile matter, 1 per cent sulphur, 9 per cent ash, and 14,000 B. t. u., "dry coal." Price, $2.45 per ton (2,000 pounds).

61. Bituminous coal delivered to the United States engineer office, Pascagoula, Miss., War Department, 1914–15. Contract guaranties same as No. 60. Price, $2.90 per ton (2,000 pounds).

62. Bituminous coal delivered to the United States engineer office, Gulfport, Miss., War Department, 1914–15. Contract guaranties same as No. 60. Price, $3.05 per ton (2,000 pounds).

63. Bituminous coal delivered to the United States engineer office, Mobile, Ala., and Pascagoula, Miss., War Department, 1914–15. Contract guaranties: 2.97 per cent moisture, "as received"; 31.74 per cent volatile matter, 0.625 per cent sulphur, 7.185 per cent ash, and 14,250 B. t. u., "dry coal." Price, $1.38 per ton f. o. b. mines (2,000 pounds).

64. Bituminous coal delivered to Fort Barrancas, Fla., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 1 per cent moisture, "as received"; 7 per cent ash, 13,500 B. t. u., "dry coal." Price, $4.25 per ton in vessels and $4.35 per ton at pumping plant.

65. Bituminous coal delivered to Forts Barrancas and Pickens, Fla., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 2 per cent moisture, "as received"; 7.5 per cent ash, 13,600 B. t. u., "dry coal." Price, $4.37 per ton at Fort Barrancas pumping plant, $5.20 per ton at Fort Pickens, and $7 per ton at mortar battery, Fort Pickens.

66. Bituminous coal delivered to Forts Barrancas, McRee, and Pickens, Fla., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 2 per cent moisture "as received"; 31 per cent volatile matter, 1 per cent sulphur, 7.5 per cent ash, and 13,700 B. t. u., "dry coal." Price, $5.20 per ton at Fort Pickens, $4.37 per ton at Fort Barrancas, and $7.25 per ton at Fort McRee.

67. Bituminous coal delivered to the customhouse, New Orleans, La., Treasury Department, 1909–10. Contract guaranties: 6 per cent ash, "dry coal"; 14,500 B. t. u., "as received." Price, $3.25 per ton.

68. Bituminous coal delivered to the mint building, New Orleans, La., Treasury Department, 1909–10. Contract guaranties same as No. 67. Price, $3.25 per ton.

69. Bituminous coal delivered to the customhouse, New Orleans, La., Treasury Department, 1907–8. Contract guaranties: 8.5 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3.75 per ton.

70. Bituminous coal delivered to the United States engineer office, Mobile, Ala., War Department, 1914–15. Price, $1.36 per ton f. o. b. mines.

71. Bituminous coal delivered to Forts Barrancas and Pickens, Fla., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 8 per cent moisture, "as received"; 30 per cent volatile matter, 1.25 per cent sulphur, 7.5 per cent ash, and 14,000 B. t. u., "dry coal." Price, $4.35 per ton at Fort Barrancas, Fla., and $5.15 per ton at Fort Pickens (mortar battery).

72. Bituminous coal delivered to Fort Barrancas, Fla., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 4 per cent ash, "dry coal"; 14,800 B. t. u., "as received." Price, $4.03 per ton.

73. Bituminous coal delivered to Forts Barrancas and McRee, Fla., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 1.5 per cent moisture, "as received"; 8 per cent ash, 14,000 B. t. u., "dry coal." Price, $4.40 at Fort Barrancas and $7.30 at Fort McRee.

74. Bituminous coal delivered to the eighth lighthouse district, New Orleans, La., Bureau of Lighthouses, Department of Commerce, 1912–13. Contract guaranties: 10 per cent ash, "dry coal"; 13,500 B. t. u., "as received." Price, $3.90 per ton.

75. Bituminous coal delivered to the eighth lighthouse district, New Orleans, La., Bureau of Lighthouses, Department of Commerce, 1914–15. Contract guaranties: 3 per cent moisture, "as received"; 29 per cent volatile matter, 1 per cent sulphur, 10 per cent ash, and 13,600 B. t. u., "dry coal." Price, $3.90 per ton.

76. Bituminous coal delivered to the navy yard at Pensacola, Fla., Navy Department, in June, 1914.

77. Bituminous coal delivered to the customhouse, New Orleans, La., Treasury Department, 1910–11. Contract guaranties: 6 per cent ash, "dry coal"; 14,500 B. t. u., "as received." Price, $3.50 per ton.

78. Bituminous coal delivered to the customhouse, New Orleans, La., Treasury Department, 1912–13. Contract guaranties: 35 per cent volatile matter, 2.5 per cent sulphur, 7 per cent ash, "dry coal"; 14,250 B. t. u., "as received." Price, $4 per ton.

79. Bituminous coal delivered to the navy yard at Pensacola, Fla., Navy Department, in June, 1914.

80. Bituminous coal delivered to the eighth lighthouse district, New Orleans, La., Bureau of Lighthouses, Department of Commerce, 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 35 per cent volatile matter, 2 per cent sulphur, 10 per cent ash, 13,500 B. t. u., "dry coal." Price, $3.90 per ton.

81. Bituminous coal delivered to Fort Morgan, Ala., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 4 per cent moisture, "as received"; 35 per cent volatile matter, 0.75 per cent sulphur, 7 per cent ash, and 14,000 B. t. u., "dry coal." Price, $4.80 per ton.

82. Bituminous coal delivered to the United States engineer office, Tuscaloosa, Ala., War Department, 1914–15. Contract guaranties: 3 per cent moisture, "as received"; 35 per cent volatile matter, 1.25 per cent sulphur, 13 per cent ash, and 13,000 B. t. u., "dry coal." Price, $1.50 per ton (2,000 pounds).

83. Bituminous coal delivered to the customhouse, New Orleans, La., Treasury Department, 1913–14. Contract guaranties: 10 per cent ash, "dry coal"; 13,800 B. t. u., "as received." Price, $3.30 per ton.

84. Bituminous coal delivered to Jackson Barracks, La., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 3 per cent moisture, "as received"; 12 per cent ash, and 13,500 B. t. u., "dry coal." Price, $4.50 per ton.

85. Bituminous coal delivered to the United States engineer office, Port Eads and Burrwood, La., and to points on the Mississippi River below Plaquemine, La., War Department, 1914–15. Contract guaranties: 3 per cent moisture, "as received"; 33.92 per cent volatile matter for 5-inch coal and 32.92 per cent for 3-inch coal, 1 per cent sulphur, 4 per cent ash for 5-inch coal and 6 per cent for 3-inch coal, 14,700 B. t. u. for 5-inch coal and 14,500 for 3-inch coal, "dry coal." Price, $3.75 per ton (2,000 pounds) for the 5-inch coal and $3.65 for the 3-inch coal.

86. Bituminous coal delivered to Jackson Barracks, La., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 3 per cent moisture,

"as received"; 9 per cent ash, 13,200 B. t. u., "dry coal." Price, $5.75 per ton.

ARKANSAS COALS.

87. Semibituminous coal delivered to Fort Sam Houston, Tex., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 3 per cent moisture, "as received"; 10 per cent ash, 14,000 B. t. u., "dry coal." Price, $6.869 per ton.

88. Semibituminous coal delivered to Fort Sam Houston, Tex., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 2 per cent moisture, "as received"; 17 per cent volatile matter, 1 per cent sulphur, 6 per cent ash, 14,000 B. t. u., "dry coal." Price, $6.10 per ton.

89. Semibituminous coal delivered to Fort Logan H. Roots, Ark., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 10 per cent ash, "dry coal"; 13,500 B. t. u., "as received." Price, $6.28 per ton.

90. Semibituminous coal delivered to Fort Logan H. Roots, Ark., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 3 per cent moisture, "as received"; 10 per cent ash, 13,500 B. t. u., "dry coal." Price, $5.70 per ton.

91. Semibituminous coal delivered to Fort Logan H. Roots, Ark., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 11 per cent ash, "dry coal"; 13,000 B. t. u., "as received." Price, $5.43 per ton.

92. Semibituminous coal delivered to Fort Logan H. Roots, Ark., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 3 per cent moisture, "as received"; 10 per cent ash, 13,000 B. t. u., "dry coal." Price, $4.15 per ton.

93. Semibituminous coal delivered to Fort Logan H. Roots, Ark., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 3.5 per cent moisture, "as received"; 10 per cent ash, 13,500 B. t. u., "dry coal." Price, $5.88 per ton.

ARKANSAS AND OKLAHOMA COALS.

94. Semibituminous coal delivered to Fort Sam Houston, Tex., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 3 per cent moisture, "as received"; 20 per cent volatile matter, 3 per cent sulphur, 10 per cent ash, and 13,500 B. t. u., "dry coal." Price, $6.66 per ton.

COLORADO COALS.

95. Anthracite coal delivered to United States courthouse and post-office building, Denver, Colo., Treasury Department, 1910–11. Contract guaranties: 10 per cent ash, "dry coal"; 13,300 B. t. u., "as received." Price, $4.75 per ton.

96. Anthracite coal delivered to United States courthouse and post-office building, Denver, Colo., Treasury Department, 1911–12. Contract guaranties: 16 per cent ash, "dry coal"; 11,500 B. t. u., "as received." Price, $5.25 per ton.

97. Anthracite coal delivered to United States courthouse and post-office building, Denver, Colo., Treasury Department, 1912–13.

98 and 99. Anthracite coal delivered to United States courthouse and post-office building, Denver, Colo., Treasury Department. No. 98 was delivered in 1913–14 and No. 99 in 1914–15. Price, $5.40 per ton.

100. Bituminous coal delivered to Fort Meade, S. Dak., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 14 per cent ash, 12,500 B. t. u., "dry coal." Price, $7.056 per ton f. o. b. Sturgis, S. Dak.

101. Bituminous coal delivered to Fort Logan, Colo., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 2.5 per cent moisture, "as received"; 36 per cent volatile matter, 0.75 per cent sulphur, 14 per cent ash, and 12,400 B. t. u., "dry coal." Price, $4.144 per ton.

102. Bituminous coal delivered to Fort D. A. Russell, Wyo., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 11.5 per cent ash, "dry coal"; 12,500 B. t. u., "as received." Price, $4.872 per ton.

103. Bituminous coal delivered to Fort Logan, Colo., Quartermaster Corps, War Department, 1911–12. Contract guaranties same as No. 102. Price, $4.59 per ton.

104. Bituminous coal delivered to Fort Meade, S. Dak., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 3.5 per cent moisture, "as received"; 11.75 per cent ash, 12,875 B. t. u., "dry coal." Price, $7.28 per ton f. o. b. Sturgis, S. Dak.

105. Bituminous coal delivered to Fort Robinson, Nebr., Quartermaster Corps, War Department, 1912–13. Contract guaranties same as No. 104. Price, $7.28 per ton.

106. Bituminous coal delivered to the mint building, Denver, Colo., Treasury Department, 1909–10. Contract guaranties: 12 per cent ash, "dry coal"; 13,000 B. t. u., "as received." Price, $4.40 per ton.

107 and 108. Bituminous coal delivered to the Navy Department in May, 1912. No further information available.

109. Average of Nos. 107 and 108, by weight, according to the respective numbers of analyses made.

110. Bituminous coal delivered to the Navy Department in June and July, 1912. Samples collected when coal was loaded into cars at the mine.

111. Bituminous coal delivered to Fort D. A. Russell, Wyo., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 4 per cent moisture, "as received"; 11.5 per cent ash, 12,550 B. t. u., "dry coal." Price, $5.32 per ton.

112. Bituminous coal delivered to Fort Logan, Colo., Quartermaster Corps, War Department, 1912–13. Contract guaranties same as No. 111. Price, $4.368 per ton.

113. Bituminous coal delivered to Fort Logan, Colo., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 3.5 per cent moisture, "as received"; 12 per cent ash, 12,850 B. t. u., "dry coal." Price, $4.312 per ton.

114. Bituminous coal delivered to the United States Indian school, Grand Junction, Colo., Office of Indian Affairs, Department of the Interior, 1910–11. Contract guaranties: 8.5 per cent ash, "dry coal"; 11,850 B. t. u., "as received." Price, $2.75 per ton (2,000 pounds).

115. Bituminous coal delivered to the mint building, Denver, Colo., Treasury Department, 1910–11. Contract guaranties: 5 per cent ash, "dry coal"; 12,320 B. t. u., "as received." Price, $4.35 per ton.

116. Bituminous coal delivered to the mint building, Denver, Colo., Treasury Department, 1911–12. Contract guaranties: 4.9 per cent ash, "dry coal"; 12,200 B. t. u., "as received." Price, $4.09 per ton.

117. Bituminous coal delivered to the mint building, Denver, Colo., Treasury Department, 1912–13. Contract guaranties: 5 per cent ash, "dry coal"; 12,200 B. t. u., "as received." Price, $4.15 per ton.

118. Bituminous coal delivered to the mint building, Denver, Colo., Treasury Department, 1913–14. Contract guaranties: 40 per cent volatile matter, 2 per cent sulphur, 5 per cent ash, "dry coal"; 12,200 B. t. u., "as received." Price, $4.09 per ton.

119. Bituminous coal delivered to the mint building, Denver, Colo., Treasury Department, 1914–15. Contract guaranties: 5 per cent ash and 13,000 B. t. u., "dry coal." Price, $4.19 per ton.

120. Subbituminous coal delivered to the mint building, Denver, Colo., Treasury Department, 1914–15. Contract guaranties, same as No. 119. Price, $3.50 per ton.

GEORGIA COALS.

121. Semibituminous coal delivered to Fort Oglethorpe, Ga., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 6 per cent ash, "dry coal"; 14,590 B. t. u., "as received." Price, $3.36 per ton.

122. Semibituminous coal delivered to Fort Oglethorpe, Ga., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 1 per cent moisture, "as received"; 22 per cent volatile matter, 1.50 per cent sulphur, 7 per cent ash, and 14,000 B. t. u., "dry coal." Price, $3.58 per ton.

ILLINOIS COALS.

123. Bituminous coal delivered to the new post-office building, St. Louis, Mo., Treasury Department, 1911–12. Contract guaranties: 12 per cent ash, "dry coal"; 11,500 B. t. u., "as received." Price, $2.20 per ton.

124. Bituminous coal delivered to United States appraiser's stores, Chicago, Ill., Treasury Department, 1909–10. Contract guaranties: 8.9 per cent ash, "dry coal"; 12,136 B. t. u., "as received." Price, $3.04 per ton.

125. Bituminous coal delivered to the United States courthouse and post-office building, Chicago, Ill., Treasury Department, 1909–10. Contract guaranties: 8.9 per cent ash, "dry coal"; 12,136 B. t. u., "as received." Price, $3.04 per ton.

126. Bituminous coal delivered to the customhouse, St. Louis, Mo., Treasury Department, 1912–13. Contract guaranties: 40 per cent volatile matter, 3 per cent sulphur, 11 per cent ash, "dry coal"; 12,400 B. t. u., "as received." Price, $2.39 per ton.

127. Bituminous coal delivered to the post-office building, St. Louis, Mo., Treasury Department, 1912–13. Contract guaranties, same as No. 126. Price, $2.39 per ton.

128. Bituminous coal delivered to the Army Building, St. Paul, Minn., Quarmaster Corps, War Department, 1911–12. Contract guaranties: 10 per cent ash, "dry coal"; 11,515 B. t. u., "as received." Price, $2.07 per ton f. o. b. Christopher, Ill.

129. Bituminous coal delivered to the depot quartermaster, Omaha, Nebr., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 9 per cent ash, "dry coal"; 12,500 B. t. u., "as received." Price, $3.37 per ton f. o. b. cars Christopher, Ill., including storage charges at Omaha.

130. Bituminous coal delivered to the depot quartermaster, Omaha, Nebr., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 8 per cent moisture, "as received"; 9 per cent ash, 13,000 B. t. u., "dry coal." Price, $6.28 per ton, delivered in residences.

131. Bituminous coal delivered to the depot quartermaster, Omaha, Nebr., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 8 per cent moisture, "as received"; 10 per cent ash, 12,800 B. t. u., "dry coal." Price, $1.68 per ton f. o. b. Christopher, Ill.

132. Bituminous coal delivered to the post-office building, Omaha, Nebr., Treasury Department, 1913–14. Contract guaranties: 9 per cent ash, "dry coal"; 12,500 B. t. u., "as received." Price, $4.97 per ton.

133. Bituminous coal delivered to the Army Building, St. Paul, Minn., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 7 per cent moisture, "as received"; 31.5 per cent volatile matter, 4.3 per cent sulphur. 10 per cent ash, 13,172 B. t. u., "dry coal." Price, $1.80 per ton f. o. b. mines.

134. Bituminous coal delivered to Jefferson Barracks, Mo., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 10 per cent moisture, "as received"; 13 per cent ash, 12,500 B. t. u., "dry coal." Price, $2.49 per ton.

135. Bituminous coal delivered to the United States appraiser's stores, St. Louis, Mo., Treasury Department, 1910–11. Contract guaranties: 10 per cent ash, "dry coal"; 12,000 B. t. u., "as received." Price, $2.58 per ton.

136. Bituminous coal delivered to the customhouse, St. Louis, Mo., Treasury Department, 1910–11. Contract guaranties: 10 per cent ash, "dry coal"; 12,000 B. t. u., "as received." Price, $2.43 per ton.

137. Bituminous coal delivered to the customhouse, St. Louis, Mo., Treasury Department, 1909–10. Contract guaranties: 10 per cent ash, "dry coal"; 12,585 B. t. u., "as received." Price, $2.20 per ton.

138. Bituminous coal delivered to the customhouse, St. Louis, Mo., Treasury Department, 1908–9. Contract guaranties: 12 per cent ash, "dry coal"; 12,000 B. t. u., "as received." Price, $2.43 per ton.

139. Bituminous coal delivered to Jefferson Barracks, Mo., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 11 per cent ash, "dry coal"; 11,000 B. t. u., "as received." Price, $2.31 per ton.

140. Bituminous coal delivered to Jefferson Barracks, Mo., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 10 per cent moisture, "as received"; 40 per cent volatile matter, 4.5 per cent sulphur, 15 per cent ash, 12,500 B. t. u., "dry coal." Price, $2,71 per ton.

141. Bituminous coal delivered to Fort Crook, Nebr., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 10 per cent ash, "dry coal"; 11,000 B. t. u., "as received." Price, $1.51 per ton f. o. b. mines.

142. Bituminous coal delivered to the depot quartermaster, St. Louis, Mo., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 12 per cent ash, "dry coal"; 11,500 B. t. u., "as received." Price, $3.584 per ton.

143. Bituminous coal delivered to the Sac and Fox Indian School, Toledo, Iowa, Office of Indian Affairs, Department of the Interior, 1910–11. Contract guaranties: 12 per cent ash, "dry coal"; 12,000 B. t. u., "as received." Price, $1.75 per ton (2,000 pounds) f. o. b. mines.

144. Bituminous coal delivered to the post-office building, Minneapolis, Minn., Treasury Department, 1908–9. Contract guaranties: 14.78 per cent ash, "dry coal"; 12,257 B. t. u., "as received." Price, $3.95 per ton.

145. Bituminous coal delivered to the Rock Island Arsenal, Ill., War Department, 1910–11. Contract guaranties: 14 per cent ash, "dry coal"; 11,000 B. t. u., "as received." Price, $2.23 per ton.

146. Bituminous coal delivered to Fort Sheridan, Ill., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 8 per cent moisture, "as received"; 10 per cent ash, 12,800 B. t. u., "dry coal." Price, $1.68 per ton f. o. b. mines.

147. Bituminous coal delivered to Fort Snelling, Minn., Quartermaster Corps, War Department, 1912–13. Contract guaranties and price same as No. 146.

148. Bituminous coal delivered to the United States military prison, Fort Leavenworth, Kans., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 8 per cent moisture, "as received"; 38.5 per cent volatile matter, 0.85 per cent sulphur, 8 per cent ash, 13,200 B. t. u., "dry coal." Price, $1.56 per ton f. o. b. Clinch, Ill.

149. Bituminous coal delivered to Jefferson Barracks, Mo., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 9 per cent moisture, "as received"; 38.5 per cent volatile matter, 1 per cent sulphur, 8 per cent ash, and 13,200 B. t. u., "dry coal." Price, $2.67 per ton.

150. Bituminous coal delivered to the naval training station at Great Lakes, Ill., Navy Department, 1914–15. Contract guaranties: 10 per cent moisture, "as received"; 38.5 per cent volatile matter, 1 per cent sulphur, 10 per cent ash, and 12,800 B. t. u., "dry coal." Price, $1.23 per ton f. o. b. mines.

151. Bituminous coal delivered to the naval training station at Great Lakes, Ill., Navy Department, 1912–13. Contract guaranties: 10 per cent moisture, "as received"; 1.75 per cent sulphur, 12 per cent ash, 12,500 B. t. u., "dry coal." Price, $1.45 per ton f. o. b. mines.

152. Bituminous coal delivered to the naval training station at Great Lakes, Ill., Navy Department, 1912–13. Contract guaranties and price same as No. 151.

153. Bituminous coal delivered to the naval training station at Great Lakes, Ill., Navy Department, 1913–14. Contract guaranties: 9 per cent moisture, "as received"; 38.5 per cent volatile matter, 0.85 per cent sulphur, 10 per cent ash, 12,800 B. t. u., "dry coal." Price, $1.28 per ton f. o. b. mines.

154. Bituminous coal delivered to the naval training station at Great Lakes, Ill., Navy Department, 1912–13. Contract guaranties: 10 per cent moisture, "as received"; 1.75 per cent sulphur, 12 per cent ash, 12,500 B. t. u., "dry coal." Price, $1.45 per ton f. o. b. mines.

155. Bituminous coal delivered to the United States appraiser's stores, St. Louis, Mo., Treasury Department, 1911–12. Contract guaranties: 14 per cent ash, "dry coal"; 11,000 B. t. u., "as received." Price, $2.08 per ton.

156. Bituminous coal delivered to the customhouse, St. Louis, Mo., Treasury Department, 1911–12. Contract guaranties same as No. 155. Price, $2.08 per ton.

157. Bituminous coal delivered to the post office, St. Louis, Mo., Treasury Department, 1913–14. Contract guaranties: 13 per cent ash, "dry coal"; 11,370 B. t. u., "as received." Price, $2.19 per ton.

158. Bituminous coal delivered to the customhouse, St. Louis, Mo., Treasury Department, 1913–14. Contract guaranties: 13 per cent ash, "dry coal"; 11,370 B. t. u., "as received." Price, $2.19 per ton.

159. Bituminous coal delivered to the customhouse, St. Louis, Mo., Treasury Department, 1914–15. Contract guaranties: 40 per cent volatile matter, 3 per cent sulphur, and 12 per cent ash, "dry coal"; 11,370 B. t. u., "as received." Price, $2.12 per ton.

160. Bituminous coal delivered to the post office, St. Louis, Mo., Treasury Department, 1914–15. Contract guaranties same as No. 159. Price, $2.12 per ton.

161. Bituminous coal delivered to the Rock Island Arsenal, Rock Island, Ill., War Department, 1911–12. Contract guaranties: 10 per cent ash, "dry coal"; 12,000 B. t. u., "as received." Price, $3.63 per ton.

162. Bituminous coal delivered to Fort Benjamin Harrison, Ind., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 6 per cent moisture, "as received"; 9 per cent ash, 13,000 B. t. u., "dry coal." Price, $1.65 per ton f. o. b. Eldorado, Ill.

163. Bituminous coal delivered to Fort Benjamin Harrison, Ind., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 8 per cent moisture, "as received"; 40 per cent volatile matter, 3 per cent sulphur, 9 per cent ash, 13,000 B. t. u., "dry coal." Price, $1.65 per ton f. o. b. Eldorado, Ill.

164. Bituminous coal delivered to the United States courthouse and post office, Chicago, Ill., Treasury Department, 1910–11. Contract guaranties: 9.89 per cent ash, "dry coal"; 12,400 B. t. u., "as received." Price, $3.33 per ton.

165. Bituminous coal delivered to the United States appraiser's stores, Chicago, Ill., Treasury Department, 1910–11. Contract guaranties: 9.89 per cent ash, "dry coal"; 12,400 B. t. u., "as received." Price, $3.33 per ton.

166. Bituminous coal delivered to Fort Sheridan, Ill., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 8 per cent ash, "dry coal"; 12,250 B. t. u., "as received." Price, $3.70 per ton.

167. Bituminous coal delivered to the United States courthouse and post office, Chicago, Ill., Treasury Department, 1911–12. Contract guaranties: 8.5 per cent ash, "dry coal"; 12,600 B. t. u., "as received." Price, $3.18 per ton.

168. Bituminous coal delivered to the United States appraiser's stores, Chicago, Ill., Treasury Department, 1911–12. Contract guaranties, same as No. 167. Price, $3.18 per ton.

169. Bituminous coal delivered to the post office, Chicago, Ill., Treasury Department, 1912–13. Contract guaranties: 35 per cent volatile matter, "dry coal"; 2.5 per cent sulphur, 9 per cent ash, 12,200 B. t. u., "as received." Price, $3.10 per ton.

170. Bituminous coal delivered to the Rock Island Arsenal, Rock Island, Ill., War Department, 1914–15. Contract guaranties: 8 per cent moisture, "as received"; 38.10 per cent volatile matter, 2.93 per cent sulphur, 9.10 per cent ash, and 12,275 B. t. u., "dry coal." Price, $2.68 per ton.

171. Bituminous coal delivered to the Rock Island Arsenal, Rock Island, Ill., War Department, 1912–13. Contract guaranties: 8 per cent moisture, "as received"; 9 per cent ash, 13,000 B. t. u., "dry coal." Price, $3.80 per ton.

172. Bituminous coal delivered to the Rock Island Arsenal, Rock Island, Ill., War Department, 1913–14. Contract guaranties: 4 per cent moisture, "as received"; 37.89 per cent volatile matter, 2 per cent sulphur, 9 per cent ash, 13,000 B. t. u., "dry coal." Price, $3.85 per ton.

173. Bituminous coal delivered to the Rock Island Arsenal, Rock Island, Ill., War Department, 1909–10. Contract guaranties: 12 per cent ash, "dry coal"; 10,900 B. t. u., "as received." Price, $2.12 per ton.

174 and 175. Bituminous coal delivered to the Danville Branch of the National Home for Disabled Volunteer Soldiers, Danville, Ill. No. 174 was delivered in 1910–11 and No. 175 in 1911–12. Contract guaranties: 18 per cent ash, "dry coal"; 10,500 B. t. u., "as received." Price, $1.50 per ton (2,000 pounds).

176. Bituminous coal delivered to the Danville Branch of the National Home for Disabled Volunteer Soldiers, Danville, Ill., 1912–13. Contract guaranties: 13 per cent moisture, "as received"; 17 per cent ash, 11,900 B. t. u., "dry coal." Price, $1.60 per ton (2,000 pounds).

177. Bituminous coal delivered to the Danville Branch of the National Home for Disabled Volunteer Soldiers, Danville, Ill., 1913–14. Contract guaranties: 13 per cent moisture, "as received"; 40 per cent volatile matter, 3.5 per cent sulphur, 17 per cent ash, 12,000 B. t. u., "dry coal." Price, $1.60 per ton (2,000 pounds).

178. Bituminous coal delivered to the Danville Branch of the National Home for Disabled Volunteer Soldiers, Danville, Ill., 1910–11. Contract guaranties: 10 per cent ash, "dry coal"; 12,000 B. t. u., "as received." Price, $1.95 per ton (2,000 pounds).

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IOWA COALS.

194. Bituminous coal delivered to Fort Crook, Nebr., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 8 per cent moisture, "as received"; 15 per cent ash, 12,500 B. t. u., "dry coal." Price, $2.958 per ton.

KANSAS COALS.

195. Bituminous coal delivered to Fort Riley, Kans., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 5 per cent moisture, "as received"; 12 per cent ash, 13,000 B. t. u., "dry coal." Price, $4.37 per ton ($2.94 per ton at Mineral, Kans).

196. Bituminous coal delivered to Fort Riley, Kans., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 5 per cent moisture, "as received"; 35 per cent volatile matter, 5 per cent sulphur, 15 per cent ash, 12,500 B. t. u., "dry coal." Price, $2.98 per ton f. o. b. Mineral, Kans.

197. Bituminous coal delivered to Fort Riley, Kans., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 10 per cent ash, "dry coal"; 13,000 B. t. u., "as received." Price, $3.08 per ton f. o. b. Mineral, Kans.

198. Bituminous coal delivered to Fort Riley, Kans., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 18 per cent ash, "dry coal"; 11,500 B. t. u., "as received." Price, $2.41 per ton f. o. b. Mineral, Kans.

199. Bituminous coal delivered to the post office, Omaha, Nebr., Treasury Department, 1914–15. Contract guaranties: 40 per cent volatile matter, 3 per cent sulphur, and 12 per cent ash, "dry coal"; 12,000 B. t. u., "as received." Price, $4.74 per ton.

200. Bituminous coal delivered to the United States courthouse and post office, Omaha, Nebr., Treasury Department, 1908–9. Contract guaranties: 11 per cent ash, "dry coal"; 12,000 B. t. u., "as received." Price, $4.41 per ton.

201. Bituminous coal delivered to the United States courthouse and post office, Omaha, Nebr., Treasury Department, 1909–10. Contract guaranties: 11 per cent ash, "dry coal"; 12,000 B. t. u., "as received." Price, $4.64 per ton.

202. Bituminous coal delivered to the United States courthouse and post office, Omaha, Nebr., Treasury Department, 1910–11. Contract guaranties same as No. 201. Price, $5.19 per ton.

203. Bituminous coal delivered to Fort Leavenworth, Kans., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 10 per cent moisture, "as received"; 15 per cent ash, 12,500 B. t. u., "dry coal." Price, $3.08 per ton.

204. Bituminous coal delivered to Fort Leavenworth, Kans., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 15 per cent ash, "dry coal"; 10,700 B. t. u., "as received." Price, $3.70 per ton.

205. Bituminous coal delivered to the United States military prison, Fort Leavenworth, Kans., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 11 per cent ash, "dry coal"; 11,100 B. t. u., "as received." Price, $2.74 per ton.

206. Bituminous coal delivered to Fort Leavenworth, Kans., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 10 per cent moisture, "as received"; 35 per cent volatile matter, 5 per cent sulphur, 15 per cent ash, 12,500 B. t. u., "dry coal." Price, $2.90 per ton.

207. Bituminous coal delivered to the United States penitentiary, Leavenworth, Kans., Department of Justice, 1914–15. Contract guaranties same as No. 206. Price, $2.79 per ton.

208. Bituminous coal delivered to the United States military prison, Fort Leavenworth, Kans., Quartermaster Corps, War Department, 1914–15. Contract

179. Bituminous coal delivered to the Danville Branch of the National Home for Disabled Volunteer Soldiers, Danville, Ill., 1914–15. Contract guaranties: 13 per cent moisture, "as received"; 40 per cent volatile matter, 3.5 per cent sulphur, 17 per cent ash, and 12,000 B. t. u., "dry coal." Price $1.60 per ton (2,000 pounds).

180. Bituminous coal delivered to Fort Des Moines, Iowa, Quartermaster Corps, War Department, 1911–12. Contract guaranties: 9 per cent ash, "dry coal"; 12,771 B. t. u., "as received." Price, $1.80 per ton f. o. b. Carterville, Ill.

181. Bituminous coal delivered to Fort Riley, Kans., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 5.6 per cent moisture, "as received"; 29.39 per cent volatile matter, 0.7 per cent sulphur, 8.51 per cent ash, and 13,500 B. t. u., "dry coal." Price, $1.56 per ton f. o. b. Carterville, Ill.

182. Bituminous coal delivered to Fort Riley, Kans., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 5.6 per cent moisture, "as received"; 29.39 per cent volatile matter, 0.7 per cent sulphur, 8.51 per cent ash, and 13,500 B. t. u., "dry coal." Price, $0.98 per ton f. o. b. Carterville, Ill.

183. Bituminous coal delivered to Fort Des Moines, Iowa, Quartermaster Corps, War Department, 1912–13. Contract guaranties: 5.5 per cent moisture, "as received"; 9.5 per cent ash, 13,600 B. t. u., "dry coal." Price, $1.79 per ton f. o. b. Johnson City, Ill.

184. Bituminous coal delivered to United States military prison, Leavenworth, Kans., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 6 per cent moisture, "as received"; 9 per cent ash, 13,600 B. t. u., "dry coal." Price, $1.76 per ton f. o. b. Johnson City, Ill.

185. Bituminous coal delivered to Fort Omaha, Nebr., Quartermaster Corps, War Department, 1912–13. Contract guaranties and price same as No. 183.

186. Bituminous coal delivered to Fort Crook, Nebr., Quartermaster Corps, War Department, 1912–13. Contract guaranties and price same as No. 183.

187. Bituminous coal delivered to Fort Snelling, Minn., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 7.5 per cent moisture, "as received"; 8.5 per cent ash, 13,310 B. t. u., "dry coal." Price, $1.70 per ton f. o. b. Johnson City, Ill.

188. Bituminous coal delivered to Fort Sheridan, Ill., Quartermaster Corps, War Department, 1913–14. Contract guaranties same as No. 187. Price, $1.56 per ton f. o. b. Johnson City, Ill.

189. Bituminous coal delivered to Fort Crook, Nebr., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 8.5 per cent moisture, "as received"; 35 per cent volatile matter, 1 per cent sulphur, 10.5 per cent ash, and 12,800 B. t. u., "dry coal." Price, $1.23 per ton f. o. b. Johnson City, Ill.

190. Bituminous coal delivered to the depot quartermaster, St. Louis, Mo., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 10 per cent moisture, "as received"; 15 per cent ash, 12,500 B. t. u., "dry coal." Price, $3.32 per ton.

INDIANA COALS.

191 Bituminous coal delivered to Fort Benjamin Harrison, Ind., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 9.3 per cent ash, "dry coal"; 11,700 B. t. u., "as received." Price, $2.47 per ton.

192. Bituminous coal delivered to the post office, Chicago, Ill., Treasury Department, 1913–14. Contract guaranties: 8 per cent ash, "dry coal"; 12,500 B. t. u., "as received." Price, $3.21 per ton.

193. Bituminous coal delivered to the quartermaster depot, Jeffersonville, Ind., Quartermaster Corps, War Department, 1913–14.

IOWA COALS.

194. Bituminous coal delivered to Fort Crook, Nebr., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 8 per cent moisture, "as received"; 15 per cent ash, 12,500 B. t. u., "dry coal." Price, $2.958 per ton.

KANSAS COALS.

195. Bituminous coal delivered to Fort Riley, Kans., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 5 per cent moisture, "as received"; 12 per cent ash, 13,000 B. t. u., "dry coal." Price, $4.37 per ton ($2.94 per ton at Mineral, Kans).

196. Bituminous coal delivered to Fort Riley, Kans., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 5 per cent moisture, "as received"; 35 per cent volatile matter, 5 per cent sulphur, 15 per cent ash, 12,500 B. t. u., "dry coal." Price, $2.98 per ton f. o. b. Mineral, Kans.

197. Bituminous coal delivered to Fort Riley, Kans., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 10 per cent ash, "dry coal"; 13,000 B. t. u., "as received." Price, $3.08 per ton f. o. b. Mineral, Kans.

198. Bituminous coal delivered to Fort Riley, Kans., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 18 per cent ash, "dry coal"; 11,500 B. t. u., "as received." Price, $2.41 per ton f. o. b. Mineral, Kans.

199. Bituminous coal delivered to the post office, Omaha, Nebr., Treasury Department, 1914–15. Contract guaranties: 40 per cent volatile matter, 3 per cent sulphur, and 12 per cent ash, "dry coal"; 12,000 B. t. u., "as received." Price, $4.74 per ton.

200. Bituminous coal delivered to the United States courthouse and post office, Omaha, Nebr., Treasury Department, 1908–9. Contract guaranties: 11 per cent ash, "dry coal"; 12,000 B. t. u., "as received." Price, $4.41 per ton.

201. Bituminous coal delivered to the United States courthouse and post office, Omaha, Nebr., Treasury Department, 1909–10. Contract guaranties: 11 per cent ash, "dry coal"; 12,000 B. t. u., "as received." Price, $4.64 per ton.

202. Bituminous coal delivered to the United States courthouse and post office, Omaha, Nebr., Treasury Department, 1910–11. Contract guaranties same as No. 201. Price, $5.19 per ton.

203. Bituminous coal delivered to Fort Leavenworth, Kans., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 10 per cent moisture, "as received"; 15 per cent ash, 12,500 B. t. u., "dry coal." Price, $3.08 per ton.

204. Bituminous coal delivered to Fort Leavenworth, Kans., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 15 per cent ash, "dry coal"; 10,700 B. t. u., "as received." Price, $3.70 per ton.

205. Bituminous coal delivered to the United States military prison, Fort Leavenworth, Kans., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 11 per cent ash, "dry coal"; 11,100 B. t. u., "as received." Price, $2.74 per ton.

206. Bituminous coal delivered to Fort Leavenworth, Kans., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 10 per cent moisture, "as received"; 35 per cent volatile matter, 5 per cent sulphur, 15 per cent ash, 12,500 B. t. u., "dry coal." Price, $2.90 per ton.

207. Bituminous coal delivered to the United States penitentiary, Leavenworth, Kans., Department of Justice, 1914–15. Contract guaranties same as No. 206. Price, $2.79 per ton.

208. Bituminous coal delivered to the United States military prison, Fort Leavenworth, Kans., Quartermaster Corps, War Department, 1914–15. Contract

guaranties: 9 per cent moisture, "as received"; 40 per cent volatile matter, 5 per cent sulphur, 15 per cent ash, 12,500 B. t. u., "dry coal." Price, $2.90 per ton.

209. Bituminous coal delivered to Fort Leavenworth, Kans., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 10 per cent moisture, "as received"; 40 per cent volatile matter, 5 per cent sulphur, 15 per cent ash, 12,500 B. t. u., "dry coal." Price, $3 per ton.

210. Bituminous coal delivered to the United States penitentiary, Leavenworth, Kans., Department of Justice, 1912–13. Contract guaranties: 9.5 per cent moisture, "as received"; 35 per cent volatile matter, 5 per cent sulphur, 16 per cent ash, 12,000 B. t. u., "dry coal." Price, $2.86 per ton.

211. Bituminous coal delivered to the United States penitentiary, Leavenworth, Kans., Department of Justice, 1913–14. Contract guaranties: 10 per cent moisture, "as received"; 40 per cent volatile matter, 5 per cent sulphur, 16 per cent ash, 12,000 B. t. u., "dry coal." Price, $2.86 per ton.

KENTUCKY COALS.

212. Bituminous coal delivered to the United States courthouse and post office, Memphis, Tenn., Treasury Department, 1910–11. Contract guaranties: 4.45 per cent ash, "dry coal"; 14,115 B. t. u., "as received." Price, $4.60 per ton.

213. Bituminous coal delivered to Fort McPherson, Ga., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 4 per cent moisture, "as received"; 4 per cent ash, 14,400 B. t. u., "dry coal." Price, $3.02 per ton.

214. Bituminous coal delivered to the post office, Memphis, Tenn., Treasury Department, 1913–14. Price, $4.50 per ton.

215. Bituminous coal delivered to the United States courthouse and post office, Louisville, Ky., Treasury Department, 1911–12. Contract guaranties: 8 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $2.30 per ton.

216. Bituminous coal delivered to the United States courthouse and post office, Louisville, Ky., Treasury Department, 1910–11. Contract guaranties: 10 per cent ash, "dry coal"; 13,400 B. t. u., "as received." Price, $2.35 per ton.

217. Bituminous coal delivered to the United States courthouse and post office, Louisville, Ky., Treasury Department, 1907–8. Contract guaranties: 11.5 per cent ash, "dry coal"; 12,200 B. t. u., "as received." Price, $1.95 per ton.

218. Bituminous coal delivered to the Jeffersonville depot, Indiana, Quartermaster Corps, War Department, 1913–14. Price, $2.33 per ton.

219. Bituminous coal delivered to the United States engineer office at Greenville and Vicksburg, Miss., and the mouth of the White River, Ark., War Department, 1913–14. Contract guaranties: 3.04 per cent moisture, "as received"; 39.5 per cent volatile matter, 3.11 per cent sulphur, 8.5 per cent ash, 13,000 B. t. u., "dry coal." Price, $2.50 per ton (2,000 pounds).

220. Bituminous coal delivered to the United States engineer office, White River, Ark., and Greenville and Vicksburg, Miss., War Department, 1914–15. Contract guaranties: 3.6 per cent moisture, "as received"; 39.5 per cent volatile matter, 3.1 per cent sulphur, 9 per cent ash, 13,200 B. t. u., "dry coal." Price, $2.75 per ton (2,000 pounds).

221. Bituminous coal delivered to the quartermaster depot, Jeffersonville, Ind., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 4.09 per cent moisture, "as received"; 35.54 per cent volatile matter, 1.1 per cent sulphur, 7.79 per cent ash, and 13,737 B. t. u., "dry coal." Price, $2.33 per ton.

222. Bituminous coal delivered to Fort McPherson, Ga., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 2.5 per cent moisture, "as received"; 5 per cent ash, 14,300 B. t. u., "dry coal." Price, $3.30 per ton.

223. Bituminous coal delivered to Fort McPherson, Ga., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 2.5 per cent moisture, "as received"; 4 per cent ash, 14,400 B. t. u., "dry coal." Price, $3.57 per ton.

MARYLAND COALS.

224. Semibituminous coal delivered to Fort Howard, Md., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 2.5 per cent moisture, "as received"; 7.5 per cent ash, 14,500 B. t. u., "dry coal." Price, $4.35 per ton.

225. Semibituminous coal delivered to the third lighthouse district, Tompkinsville, N. Y., Bureau of Lighthouses, Department of Commerce, 1913–14. Contract guaranties: 22 per cent volatile matter, 2 per cent sulphur, 7 per cent ash, 14,000 B. t. u., "dry coal." Price, $4.45 per ton.

226. Semibituminous coal delivered to the Government Hospital for the Insane, Washington, D. C., Department of the Interior, 1913–14. Contract guaranties: 1.25 per cent moisture, "as received"; 8 per cent ash, 14,000 B. t. u., "dry coal." Price $3.35 per ton.

227. Semibituminous coal delivered to Fort Washington, Md., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 7 per cent ash, "dry coal"; 14,250 B. t. u., "as received." Price, $4.09 per ton.

228. Semibituminous coal delivered to the naval hospital, Washington, D. C., Navy Department, 1912–13. Contract guaranties: 3 per cent moisture, "as received"; 19.5 per cent volatile matter, 1.1 per cent sulphur, 7.5 per cent ash, 14,300 B. t. u., "dry coal." Price, $3.55 per ton.

229. Semibituminous coal delivered to the Columbia Institution for the Deaf, Kendall Green, D. C., 1912–13. Contract guaranties and price same as No. 228.

230. Semibituminous coal delivered to the sewage pumping station, Washington, D. C., 1912–13. Contract guaranties: 3 per cent moisture, "as received"; 7.5 per cent ash, 14,400 B. t. u., "dry coal." Price, $3.17 per ton.

231. Semibituminous coal delivered to the naval hospital, Washington, D. C., Navy Department, 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 19.5 per cent volatile matter, 1.1 per cent sulphur, 8 per cent ash, 14,250 B. t. u., "dry coal." Price, $3.70 per ton.

232. Semibituminous coal delivered to the sewage pumping station, Washington, D. C., 1913–14. Contract guaranties same as No. 231. Price, $3.32 per ton.

233. Semibituminous coal delivered to the Weather Bureau, Bluemont, Va., Department of Agriculture, 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 19.5 per cent volatile matter, 1.1 per cent sulphur, 7 per cent ash, 14,350 B. t. u., "dry coal." Price, $4 per ton.

234. Semibituminous coal delivered to the Columbia Institution for the Deaf, Washington, D. C., 1913–14. Contract guaranties same as No. 231. Price, $3.70 per ton.

235. Semibituminous coal delivered to the navy yard at Philadelphia, Pa., Navy Department, 1914–15. Contract guaranties: 1.50 per cent moisture, "as received"; 19.29 per cent volatile matter, 1 per cent sulphur, 7.61 per cent ash, 14,533 B. t. u., "dry coal." Price, $2.92 per ton f. o. b. vessels at coal piers, $3.09 per ton f. o. b. barges alongside navy yard, and $3.25 per ton f. o. b. cars at navy yard.

236. Semibituminous coal delivered to the United States Naval Academy, Annapolis, Md., Navy Department, 1914–15. Contract guaranties same as No. 235. Price, $3.15 per ton at wharf, Naval Academy, and $3.65 per ton stored aboard or ashore.

237. Semibituminous coal delivered to the sewage pumping station, Washington, D. C., 1914–15. Contract guaranties: 3 per cent moisture, "as received"; 19.50 per cent volatile matter, 1.10 per cent sulphur, 8 per cent ash, 14,280 B. t. u., "dry coal." Price, $3.40 per ton.

238. Semibituminous coal delivered to the naval hospital, Washington, D. C., Navy Department, 1914–15. Price, $3.87 per ton.

239. Semibituminous coal delivered to the District of Columbia Workhouse, Occoquan, Va., 1914–15. Contract guaranties: 3 per cent moisture, "as received"; 19.50 per cent volatile matter, 1.10 per cent sulphur, 8 per cent ash, 14,250 B. t. u., "dry coal." Price, $3.49 per ton.

240. Semibituminous coal delivered to the Columbia Institute for the Deaf, Washington, D. C., 1914–15. Contract guaranties same as No. 239. Price, $3.70 per ton.

241. Semibituminous coal delivered to the United States Navy, Curtis Bay, Md., Navy Department, 1914–15. Contract guaranties: 1.50 per cent moisture, "as received"; 19.29 per cent volatile matter, 1 per cent sulphur, 7.61 per cent ash, 14,533 B. t. u., "dry coal." Price, $2.85 per ton.

242. Semibituminous coal delivered to the Naval Academy, Annapolis, Md., Navy Department, 1913–14. Contract guaranties: 2 per cent moisture, "as received"; 19 per cent volatile matter, 1.25 per cent sulphur, 8 per cent ash, 14,400 B. t. u., "dry coal." Price, $3.01 per ton.

243. Semibituminous coal delivered to the naval engineering experiment station, Annapolis, Md., Navy Department, 1913–14. Contract guaranties same as No. 242. Price, $3.03 per ton.

244. Semibituminous coal delivered to the Government Hospital for the Insane, Washington, D. C., Department of the Interior, 1914–15. Contract guaranties: 2.5 per cent moisture, "as received"; 19 per cent volatile matter, 1.25 per cent sulphur, 7 per cent ash, 14,500 B. t. u., "dry coal." Price, $3.06 per ton.

245. Semibituminous coal delivered to the United States Naval Academy, Annapolis, Md., Navy Department, 1914–15. Contract guaranties: 2.5 per cent moisture, "as received"; 19 per cent volatile matter, 1.25 per cent sulphur, 8 per cent ash, 14,400 B. t. u., "dry coal." Price, $3.04 per ton by water, $3.05 per ton by rail.

246. Semibituminous coal delivered to the fifth lighthouse district, Baltimore, Md., Bureau of Lighthouses, Department of Commerce, 1914–15. Contract guaranties: 2.5 per cent moisture, "as received"; 19 per cent volatile matter, 1 per cent sulphur, 7 per cent ash, 14,400 B. t. u., "dry coal." Price, $2.94 per ton.

247. Semibituminous coal delivered to the naval hospital, Washington, D. C., Navy Department, 1910–11. Contract guaranties: 7 per cent ash, "dry coal"; 14,200 B. t. u., "as received." Price, $3.37 per ton.

248. Semibituminous coal delivered to Fort Constitution, N. H., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 9 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $4.35 per ton.

249. Semibituminous coal delivered to Fort Strong, Mass., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 8 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $5.05 per ton.

250. Semibituminous coal delivered to Fort Warren, Mass., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 2 per cent moisture,

"as received"; 22 per cent volatile matter, 2 per cent sulphur, 8 per cent ash, 14,200 B. t. u., "dry coal." Price, $5.29 per ton.

251. Semibituminous coal delivered to Fort Strong, Mass., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 2 per cent moisture, "as received"; 8 per cent ash, 14,200 B. t. u., "dry coal." Price, $5.29 per ton.

252. Semibituminous coal delivered to Fort Constitution, N. H. (for vessels), Quartermaster Corps, War Department, 1913–14. Contract guaranties: 2 per cent moisture, "as received"; 8.5 per cent ash, 14,100 B. t. u., "dry coal." Price, $4.70 per ton delivered at Portsmouth, N. H.

253. Semibituminous coal delivered to the Government Hospital for the Insane, Washington, D. C., Department of the Interior, 1912–13. Contract guaranties: 3 per cent moisture, "as received"; 10 per cent ash, 14,000 B. t. u., "dry coal." Price, $2.75 per ton.

254. Semibituminous coal delivered to the Government Hospital for the Insane, Washington, D. C., Department of the Interior, 1913–14. Contract guaranties: 2 per cent moisture, "as received"; 7 per cent ash, 14,000 B. t. u., "dry coal." Price, $2.90 per ton.

MICHIGAN COALS.

255. Bituminous coal delivered to the United States Indian school, Mount Pleasant, Mich., Office of Indian Affairs, Department of the Interior, 1910–11. Contract guaranties: 8.5 per cent ash "dry coal"; 11,675 B. t. u., "as received." Price $3.29 per ton (2,000 pounds).

MISSOURI COALS.

256. Bituminous coal delivered to Fort Crook, Nebr., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 14 per cent ash, "dry coal"; 10,600 B. t. u., "as received." Price, $4.25 per ton.

MONTANA COALS.

257. Subbituminous coal delivered to the post office, Helena, Mont., Treasury Department, 1910–11. Contract guaranties: 10 per cent ash, "dry coal"; 10,940 B. t. u., "as received." Price, $3.36 per ton.

258. Subbituminous coal delivered to Fort Missoula, Mont., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 10.49 per cent ash, "dry coal"; 10,922 B. t. u., "as received." Price, $2.80 and $3.08 per ton f. o. b. mines (according to months of delivery).

259. Subbituminous coal delivered to Fort William Henry Harrison, Mont., Quartermaster Corps, War Department, 1911–12. Contract guaranties same as No. 258. Price, $2.80 and $3.08 f. o. b. mines (according to months of delivery).

260. Subbituminous coal delivered to Fort Missoula, Mont., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 8.62 per cent moisture, "as received"; 8.25 per cent ash, 12,980 B. t. u., "dry coal." Price, $3.696 and $3.976 per ton (according to months of delivery).

261. Subbituminous coal delivered to Fort Yellowstone, Wyo., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 8.62 per cent moisture, "as received"; 8.25 per cent ash, 12,980 B. t. u., "dry coal." Price, $2.856 per ton for July, August, and March to June inclusive, and $3.136 per ton for September to February, inclusive, f. o. b. mines.

119. Bituminous coal delivered to the mint building, Denver, Colo., Treasury Department, 1914–15. Contract guaranties: 5 per cent ash and 13,000 B. t. u., "dry coal." Price, $4.19 per ton.

120. Subbituminous coal delivered to the mint building, Denver, Colo., Treasury Department, 1914–15. Contract guaranties, same as No. 119. Price, $3.50 per ton.

GEORGIA COALS.

121. Semibituminous coal delivered to Fort Oglethorpe, Ga., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 6 per cent ash, "dry coal"; 14,590 B. t. u., "as received." Price, $3.36 per ton.

122. Semibituminous coal delivered to Fort Oglethorpe, Ga., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 1 per cent moisture, "as received"; 22 per cent volatile matter, 1.50 per cent sulphur, 7 per cent ash, and 14,000 B. t. u., "dry coal." Price, $3.58 per ton.

ILLINOIS COALS.

123. Bituminous coal delivered to the new post-office building, St. Louis, Mo., Treasury Department, 1911–12. Contract guaranties: 12 per cent ash, "dry coal"; 11,500 B. t. u., "as received." Price, $2.20 per ton.

124. Bituminous coal delivered to United States appraiser's stores, Chicago, Ill., Treasury Department, 1909–10. Contract guaranties: 8.9 per cent ash, "dry coal"; 12,136 B. t. u., "as received." Price, $3.04 per ton.

125. Bituminous coal delivered to the United States courthouse and post-office building, Chicago, Ill., Treasury Department, 1909–10. Contract guaranties: 8.9 per cent ash, "dry coal"; 12,136 B. t. u., "as received." Price, $3.04 per ton.

126. Bituminous coal delivered to the customhouse, St. Louis, Mo., Treasury Department, 1912–13. Contract guaranties: 40 per cent volatile matter, 3 per cent sulphur, 11 per cent ash, "dry coal"; 12,400 B. t. u., "as received." Price, $2.39 per ton.

127. Bituminous coal delivered to the post-office building, St. Louis, Mo., Treasury Department, 1912–13. Contract guaranties, same as No. 126. Price, $2.39 per ton.

128. Bituminous coal delivered to the Army Building, St. Paul, Minn., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 10 per cent ash, "dry coal"; 11,515 B. t. u., "as received." Price, $2.07 per ton f. o. b. Christopher, Ill.

129. Bituminous coal delivered to the depot quartermaster, Omaha, Nebr., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 9 per cent ash, "dry coal"; 12,500 B. t. u., "as received." Price, $3.37 per ton f. o. b. cars Christopher, Ill., including storage charges at Omaha.

130. Bituminous coal delivered to the depot quartermaster, Omaha, Nebr., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 8 per cent moisture, "as received"; 9 per cent ash, 13,000 B. t. u., "dry coal." Price, $6.28 per ton, delivered in residences.

131. Bituminous coal delivered to the depot quartermaster, Omaha, Nebr., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 8 per cent moisture, "as received"; 10 per cent ash, 12,800 B. t. u., "dry coal." Price, $1.68 per ton f. o. b. Christopher, Ill.

132. Bituminous coal delivered to the post-office building, Omaha, Nebr., Treasury Department, 1913–14. Contract guaranties: 9 per cent ash, "dry coal"; 12,500 B. t. u., "as received." Price, $4.97 per ton.

133. Bituminous coal delivered to the Army Building, St. Paul, Minn., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 7 per cent moisture, "as received"; 31.5 per cent volatile matter, 4.3 per cent sulphur. 10 per cent ash, 13,172 B. t. u., "dry coal." Price, $1.80 per ton f. o. b. mines.

134. Bituminous coal delivered to Jefferson Barracks, Mo., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 10 per cent moisture, "as received"; 13 per cent ash, 12,500 B. t. u., "dry coal." Price, $2.49 per ton.

135. Bituminous coal delivered to the United States appraiser's stores, St. Louis, Mo., Treasury Department, 1910–11. Contract guaranties: 10 per cent ash, "dry coal"; 12,000 B. t. u., "as received." Price, $2.58 per ton.

136. Bituminous coal delivered to the customhouse, St. Louis, Mo., Treasury Department, 1910–11. Contract guaranties: 10 per cent ash, "dry coal"; 12,000 B. t. u., "as received." Price, $2.43 per ton.

137. Bituminous coal delivered to the customhouse, St. Louis, Mo., Treasury Department, 1909–10. Contract guaranties: 10 per cent ash, "dry coal"; 12,585 B. t. u., "as received." Price, $2.20 per ton.

138. Bituminous coal delivered to the customhouse, St. Louis, Mo., Treasury Department, 1908–9. Contract guaranties: 12 per cent ash, "dry coal"; 12,000 B. t. u., "as received." Price, $2.43 per ton.

139. Bituminous coal delivered to Jefferson Barracks, Mo., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 11 per cent ash, "dry coal"; 11,000 B. t. u., "as received." Price, $2.31 per ton.

140. Bituminous coal delivered to Jefferson Barracks, Mo., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 10 per cent moisture, "as received"; 40 per cent volatile matter, 4.5 per cent sulphur, 15 per cent ash, 12,500 B. t. u., "dry coal." Price, $2,71 per ton.

141. Bituminous coal delivered to Fort Crook, Nebr., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 10 per cent ash, "dry coal"; 11,000 B. t. u., "as received." Price, $1.51 per ton f. o. b. mines.

142. Bituminous coal delivered to the depot quartermaster, St. Louis, Mo., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 12 per cent ash, "dry coal"; 11,500 B. t. u., "as received." Price, $3.584 per ton.

143. Bituminous coal delivered to the Sac and Fox Indian School, Toledo, Iowa, Office of Indian Affairs, Department of the Interior, 1910–11. Contract guaranties: 12 per cent ash, "dry coal"; 12,000 B. t. u., "as received." Price, $1.75 per ton (2,000 pounds) f. o. b. mines.

144. Bituminous coal delivered to the post-office building, Minneapolis, Minn., Treasury Department, 1908–9. Contract guaranties: 14.78 per cent ash, "dry coal"; 12,257 B. t. u., "as received." Price, $3.95 per ton.

145. Bituminous coal delivered to the Rock Island Arsenal, Ill., War Department, 1910–11. Contract guaranties: 14 per cent ash, "dry coal"; 11,000 B. t. u., "as received." Price, $2.23 per ton.

146. Bituminous coal delivered to Fort Sheridan, Ill., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 8 per cent moisture, "as received"; 10 per cent ash, 12,800 B. t. u., "dry coal." Price, $1.68 per ton f. o. b. mines.

147. Bituminous coal delivered to Fort Snelling, Minn., Quartermaster Corps, War Department, 1912–13. Contract guaranties and price same as No. 146.

148. Bituminous coal delivered to the United States military prison, Fort Leavenworth, Kans., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 8 per cent moisture, "as received"; 38.5 per cent volatile matter, 0.85 per cent sulphur, 8 per cent ash, 13,200 B. t. u., "dry coal." Price, $1.56 per ton f. o. b. Clinch, Ill.

149. Bituminous coal delivered to Jefferson Barracks, Mo., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 9 per cent moisture, "as received"; 38.5 per cent volatile matter, 1 per cent sulphur, 8 per cent ash, and 13,200 B. t. u., "dry coal." Price, $2.67 per ton.

150. Bituminous coal delivered to the naval training station at Great Lakes, Ill., Navy Department, 1914–15. Contract guaranties: 10 per cent moisture, "as received"; 38.5 per cent volatile matter, 1 per cent sulphur, 10 per cent ash, and 12,800 B. t. u., "dry coal." Price, $1.23 per ton f. o. b. mines.

151. Bituminous coal delivered to the naval training station at Great Lakes, Ill., Navy Department, 1912–13. Contract guaranties: 10 per cent moisture, "as received"; 1.75 per cent sulphur, 12 per cent ash, 12,500 B. t. u., "dry coal." Price, $1.45 per ton f. o. b. mines.

152. Bituminous coal delivered to the naval training station at Great Lakes, Ill., Navy Department, 1912–13. Contract guaranties and price same as No. 151.

153. Bituminous coal delivered to the naval training station at Great Lakes, Ill., Navy Department, 1913–14. Contract guaranties: 9 per cent moisture, "as received"; 38.5 per cent volatile matter, 0.85 per cent sulphur, 10 per cent ash, 12,800 B. t. u., "dry coal." Price, $1.28 per ton f. o. b. mines.

154. Bituminous coal delivered to the naval training station at Great Lakes, Ill., Navy Department, 1912–13. Contract guaranties: 10 per cent moisture, "as received"; 1.75 per cent sulphur, 12 per cent ash, 12,500 B. t. u., "dry coal." Price, $1.45 per ton f. o. b. mines.

155. Bituminous coal delivered to the United States appraiser's stores, St. Louis, Mo., Treasury Department, 1911–12. Contract guaranties: 14 per cent ash, "dry coal"; 11,000 B. t. u., "as received." Price, $2.08 per ton.

156. Bituminous coal delivered to the customhouse, St. Louis, Mo., Treasury Department, 1911–12. Contract guaranties same as No. 155. Price, $2.08 per ton.

157. Bituminous coal delivered to the post office, St. Louis, Mo., Treasury Department, 1913–14. Contract guaranties: 13 per cent ash, "dry coal"; 11,370 B. t. u., "as received." Price, $2.19 per ton.

158. Bituminous coal delivered to the customhouse, St. Louis, Mo., Treasury Department, 1913–14. Contract guaranties: 13 per cent ash, "dry coal"; 11,370 B. t. u., "as received." Price, $2.19 per ton.

159. Bituminous coal delivered to the customhouse, St. Louis, Mo., Treasury Department, 1914–15. Contract guaranties: 40 per cent volatile matter, 3 per cent sulphur, and 12 per cent ash, "dry coal"; 11,370 B. t. u., "as received." Price, $2.12 per ton.

160. Bituminous coal delivered to the post office, St. Louis, Mo., Treasury Department, 1914–15. Contract guaranties same as No. 159. Price, $2.12 per ton.

161. Bituminous coal delivered to the Rock Island Arsenal, Rock Island, Ill., War Department, 1911–12. Contract guaranties: 10 per cent ash, "dry coal"; 12,000 B. t. u., "as received." Price, $3.63 per ton.

162. Bituminous coal delivered to Fort Benjamin Harrison, Ind., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 6 per cent moisture, "as received"; 9 per cent ash, 13,000 B. t. u., "dry coal." Price, $1.65 per ton f. o. b. Eldorado, Ill.

163. Bituminous coal delivered to Fort Benjamin Harrison, Ind., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 8 per cent moisture, "as received"; 40 per cent volatile matter, 3 per cent sulphur, 9 per cent ash, 13,000 B. t. u., "dry coal." Price, $1.65 per ton f. o. b. Eldorado, Ill.

164. Bituminous coal delivered to the United States courthouse and post office, Chicago, Ill., Treasury Department, 1910–11. Contract guaranties: 9.89 per cent ash, "dry coal"; 12,400 B. t. u., "as received." Price, $3.33 per ton.

165. Bituminous coal delivered to the United States appraiser's stores, Chicago, Ill., Treasury Department, 1910–11. Contract guaranties: 9.89 per cent ash, "dry coal"; 12,400 B. t. u., "as received." Price, $3.33 per ton.

166. Bituminous coal delivered to Fort Sheridan, Ill., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 8 per cent ash, "dry coal"; 12,250 B. t. u., "as received." Price, $3.70 per ton.

167. Bituminous coal delivered to the United States courthouse and post office, Chicago, Ill., Treasury Department, 1911–12. Contract guaranties: 8.5 per cent ash, "dry coal"; 12,600 B. t. u., "as received." Price, $3.18 per ton.

168. Bituminous coal delivered to the United States appraiser's stores, Chicago, Ill., Treasury Department, 1911–12. Contract guaranties, same as No. 167. Price, $3.18 per ton.

169. Bituminous coal delivered to the post office, Chicago, Ill., Treasury Department, 1912–13. Contract guaranties: 35 per cent volatile matter, "dry coal"; 2.5 per cent sulphur, 9 per cent ash, 12,200 B. t. u., "as received." Price, $3.10 per ton.

170. Bituminous coal delivered to the Rock Island Arsenal, Rock Island, Ill., War Department, 1914–15. Contract guaranties: 8 per cent moisture, "as received"; 38.10 per cent volatile matter, 2.93 per cent sulphur, 9.10 per cent ash, and 12,275 B. t. u., "dry coal." Price, $2.68 per ton.

171. Bituminous coal delivered to the Rock Island Arsenal, Rock Island, Ill., War Department, 1912–13. Contract guaranties: 8 per cent moisture, "as received"; 9 per cent ash, 13,000 B. t. u., "dry coal." Price, $3.80 per ton.

172. Bituminous coal delivered to the Rock Island Arsenal, Rock Island, Ill., War Department, 1913–14. Contract guaranties: 4 per cent moisture, "as received"; 37.89 per cent volatile matter, 2 per cent sulphur, 9 per cent ash, 13,000 B. t. u., "dry coal." Price, $3.85 per ton.

173. Bituminous coal delivered to the Rock Island Arsenal, Rock Island, Ill., War Department, 1909–10. Contract guaranties: 12 per cent ash, "dry coal"; 10,900 B. t. u., "as received." Price, $2.12 per ton.

174 and 175. Bituminous coal delivered to the Danville Branch of the National Home for Disabled Volunteer Soldiers, Danville, Ill. No. 174 was delivered in 1910–11 and No. 175 in 1911–12. Contract guaranties: 18 per cent ash, "dry coal"; 10,500 B. t. u., "as received." Price, $1.50 per ton (2,000 pounds).

176. Bituminous coal delivered to the Danville Branch of the National Home for Disabled Volunteer Soldiers, Danville, Ill., 1912–13. Contract guaranties: 13 per cent moisture, "as received"; 17 per cent ash, 11,900 B. t. u., "dry coal." Price, $1.60 per ton (2,000 pounds).

177. Bituminous coal delivered to the Danville Branch of the National Home for Disabled Volunteer Soldiers, Danville, Ill., 1913–14. Contract guaranties: 13 per cent moisture, "as received"; 40 per cent volatile matter, 3.5 per cent sulphur, 17 per cent ash, 12,000 B. t. u., "dry coal." Price, $1.60 per ton (2,000 pounds).

178. Bituminous coal delivered to the Danville Branch of the National Home for Disabled Volunteer Soldiers, Danville, Ill., 1910–11. Contract guaranties: 10 per cent ash, "dry coal"; 12,000 B. t. u., "as received." Price, $1.95 per ton (2,000 pounds).

179. Bituminous coal delivered to the Danville Branch of the National Home for Disabled Volunteer Soldiers, Danville, Ill., 1914–15. Contract guaranties: 13 per cent moisture, "as received"; 40 per cent volatile matter, 3.5 per cent sulphur, 17 per cent ash, and 12,000 B. t. u., "dry coal." Price $1.60 per ton (2,000 pounds).

180. Bituminous coal delivered to Fort Des Moines, Iowa, Quartermaster Corps, War Department, 1911–12. Contract guaranties: 9 per cent ash, "dry coal"; 12,771 B. t. u., "as received." Price, $1.80 per ton f. o. b. Carterville, Ill.

181. Bituminous coal delivered to Fort Riley, Kans., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 5.6 per cent moisture, "as received"; 29.39 per cent volatile matter, 0.7 per cent sulphur, 8.51 per cent ash, and 13,500 B. t. u., "dry coal." Price, $1.56 per ton f. o. b. Carterville, Ill.

182. Bituminous coal delivered to Fort Riley, Kans., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 5.6 per cent moisture, "as received"; 29.39 per cent volatile matter, 0.7 per cent sulphur, 8.51 per cent ash, and 13,500 B. t. u., "dry coal." Price, $0.98 per ton f. o. b. Carterville, Ill.

183. Bituminous coal delivered to Fort Des Moines, Iowa, Quartermaster Corps, War Department, 1912–13. Contract guaranties: 5.5 per cent moisture, "as received"; 9.5 per cent ash, 13,600 B. t. u., "dry coal." Price, $1.79 per ton f. o. b. Johnson City, Ill.

184. Bituminous coal delivered to United States military prison, Leavenworth, Kans., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 6 per cent moisture, "as received"; 9 per cent ash, 13,600 B. t. u., "dry coal." Price, $1.76 per ton f. o. b. Johnson City, Ill.

185. Bituminous coal delivered to Fort Omaha, Nebr., Quartermaster Corps, War Department, 1912–13. Contract guaranties and price same as No. 183.

186. Bituminous coal delivered to Fort Crook, Nebr., Quartermaster Corps, War Department, 1912–13. Contract guaranties and price same as No. 183.

187. Bituminous coal delivered to Fort Snelling, Minn., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 7.5 per cent moisture, "as received"; 8.5 per cent ash, 13,310 B. t. u., "dry coal." Price, $1.70 per ton f. o. b. Johnson City, Ill.

188. Bituminous coal delivered to Fort Sheridan, Ill., Quartermaster Corps, War Department, 1913–14. Contract guaranties same as No. 187. Price, $1.56 per ton f. o. b. Johnson City, Ill.

189. Bituminous coal delivered to Fort Crook, Nebr., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 8.5 per cent moisture, "as received"; 35 per cent volatile matter, 1 per cent sulphur, 10.5 per cent ash, and 12,800 B. t. u., "dry coal." Price, $1.23 per ton f. o. b. Johnson City, Ill.

190. Bituminous coal delivered to the depot quartermaster, St. Louis, Mo., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 10 per cent moisture, "as received"; 15 per cent ash, 12,500 B. t. u., "dry coal." Price, $3.32 per ton.

INDIANA COALS.

191 Bituminous coal delivered to Fort Benjamin Harrison, Ind., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 9.3 per cent ash, "dry coal"; 11,700 B. t. u., "as received." Price, $2.47 per ton.

192. Bituminous coal delivered to the post office, Chicago, Ill., Treasury Department, 1913–14. Contract guaranties: 8 per cent ash, "dry coal"; 12,500 B. t. u., "as received." Price, $3.21 per ton.

193. Bituminous coal delivered to the quartermaster depot, Jeffersonville, Ind., Quartermaster Corps, War Department, 1913–14.

IOWA COALS.

194. Bituminous coal delivered to Fort Crook, Nebr., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 8 per cent moisture, "as received"; 15 per cent ash, 12,500 B. t. u., "dry coal." Price, $2.958 per ton.

KANSAS COALS.

195. Bituminous coal delivered to Fort Riley, Kans., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 5 per cent moisture, "as received"; 12 per cent ash, 13,000 B. t. u., "dry coal." Price, $4.37 per ton ($2.94 per ton at Mineral, Kans).

196. Bituminous coal delivered to Fort Riley, Kans., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 5 per cent moisture, "as received"; 35 per cent volatile matter, 5 per cent sulphur, 15 per cent ash, 12,500 B. t. u., "dry coal." Price, $2.98 per ton f. o. b. Mineral, Kans.

197. Bituminous coal delivered to Fort Riley, Kans., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 10 per cent ash, "dry coal"; 13,000 B. t. u., "as received." Price, $3.08 per ton f. o. b. Mineral, Kans.

198. Bituminous coal delivered to Fort Riley, Kans., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 18 per cent ash, "dry coal"; 11,500 B. t. u., "as received." Price, $2.41 per ton f. o. b. Mineral, Kans.

199. Bituminous coal delivered to the post office, Omaha, Nebr., Treasury Department, 1914–15. Contract guaranties: 40 per cent volatile matter, 3 per cent sulphur, and 12 per cent ash, "dry coal"; 12,000 B. t. u., "as received." Price, $4.74 per ton.

200. Bituminous coal delivered to the United States courthouse and post office, Omaha, Nebr., Treasury Department, 1908–9. Contract guaranties: 11 per cent ash, "dry coal"; 12,000 B. t. u., "as received." Price, $4.41 per ton.

201. Bituminous coal delivered to the United States courthouse and post office, Omaha, Nebr., Treasury Department, 1909–10. Contract guaranties: 11 per cent ash, "dry coal"; 12,000 B. t. u., "as received." Price, $4.64 per ton.

202. Bituminous coal delivered to the United States courthouse and post office, Omaha, Nebr., Treasury Department, 1910–11. Contract guaranties same as No. 201. Price, $5.19 per ton.

203. Bituminous coal delivered to Fort Leavenworth, Kans., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 10 per cent moisture, "as received"; 15 per cent ash, 12,500 B. t. u., "dry coal." Price, $3.08 per ton.

204. Bituminous coal delivered to Fort Leavenworth, Kans., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 15 per cent ash, "dry coal"; 10,700 B. t. u., "as received." Price, $3.70 per ton.

205. Bituminous coal delivered to the United States military prison, Fort Leavenworth, Kans., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 11 per cent ash, "dry coal"; 11,100 B. t. u., "as received." Price, $2.74 per ton.

206. Bituminous coal delivered to Fort Leavenworth, Kans., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 10 per cent moisture, "as received"; 35 per cent volatile matter, 5 per cent sulphur, 15 per cent ash, 12,500 B. t. u., "dry coal." Price, $2.90 per ton.

207. Bituminous coal delivered to the United States penitentiary, Leavenworth, Kans., Department of Justice, 1914–15. Contract guaranties same as No. 206. Price, $2.79 per ton.

208. Bituminous coal delivered to the United States military prison, Fort Leavenworth, Kans., Quartermaster Corps, War Department, 1914–15. Contract

guaranties: 9 per cent moisture, "as received"; 40 per cent volatile matter, 5 per cent sulphur, 15 per cent ash, 12,500 B. t. u., "dry coal." Price, $2.90 per ton.

209. Bituminous coal delivered to Fort Leavenworth, Kans., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 10 per cent moisture, "as received"; 40 per cent volatile matter, 5 per cent sulphur, 15 per cent ash, 12,500 B. t. u., "dry coal." Price, $3 per ton.

210. Bituminous coal delivered to the United States penitentiary, Leavenworth, Kans., Department of Justice, 1912–13. Contract guaranties: 9.5 per cent moisture, "as received"; 35 per cent volatile matter, 5 per cent sulphur, 16 per cent ash, 12,000 B. t. u., "dry coal." Price, $2.86 per ton.

211. Bituminous coal delivered to the United States penitentiary, Leavenworth, Kans., Department of Justice, 1913–14. Contract guaranties: 10 per cent moisture, "as received"; 40 per cent volatile matter, 5 per cent sulphur, 16 per cent ash, 12,000 B. t. u., "dry coal." Price, $2.86 per ton.

KENTUCKY COALS.

212. Bituminous coal delivered to the United States courthouse and post office, Memphis, Tenn., Treasury Department, 1910–11. Contract guaranties: 4.45 per cent ash, "dry coal"; 14,115 B. t. u., "as received." Price, $4.60 per ton.

213. Bituminous coal delivered to Fort McPherson, Ga., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 4 per cent moisture, "as received"; 4 per cent ash, 14,400 B. t. u., "dry coal." Price, $3.02 per ton.

214. Bituminous coal delivered to the post office, Memphis, Tenn., Treasury Department, 1913–14. Price, $4.50 per ton.

215. Bituminous coal delivered to the United States courthouse and post office, Louisville, Ky., Treasury Department, 1911–12. Contract guaranties: 8 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $2.30 per ton.

216. Bituminous coal delivered to the United States courthouse and post office, Louisville, Ky., Treasury Department, 1910–11. Contract guaranties: 10 per cent ash, "dry coal"; 13,400 B. t. u., "as received." Price, $2.35 per ton.

217. Bituminous coal delivered to the United States courthouse and post office, Louisville, Ky., Treasury Department, 1907–8. Contract guaranties: 11.5 per cent ash, "dry coal"; 12,200 B. t. u., "as received." Price, $1.95 per ton.

218. Bituminous coal delivered to the Jeffersonville depot, Indiana, Quartermaster Corps, War Department, 1913–14. Price, $2.33 per ton.

219. Bituminous coal delivered to the United States engineer office at Greenville and Vicksburg, Miss., and the mouth of the White River, Ark., War Department, 1913–14. Contract guaranties: 3.04 per cent moisture, "as received"; 39.5 per cent volatile matter, 3.11 per cent sulphur, 8.5 per cent ash, 13,000 B. t. u., "dry coal." Price, $2.50 per ton (2,000 pounds).

220. Bituminous coal delivered to the United States engineer office, White River, Ark., and Greenville and Vicksburg, Miss., War Department, 1914–15. Contract guaranties: 3.6 per cent moisture, "as received"; 39.5 per cent volatile matter, 3.1 per cent sulphur, 9 per cent ash, 13,200 B. t. u., "dry coal." Price, $2.75 per ton (2,000 pounds).

221. Bituminous coal delivered to the quartermaster depot, Jeffersonville, Ind., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 4.09 per cent moisture, "as received"; 35.54 per cent volatile matter, 1.1 per cent sulphur, 7.79 per cent ash, and 13,737 B. t. u., "dry coal." Price, $2.33 per ton.

222. Bituminous coal delivered to Fort McPherson, Ga., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 2.5 per cent moisture, "as received"; 5 per cent ash, 14,300 B. t. u., "dry coal." Price, $3.30 per ton.

223. Bituminous coal delivered to Fort McPherson, Ga., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 2.5 per cent moisture, "as received"; 4 per cent ash, 14,400 B. t. u., "dry coal." Price, $3.57 per ton.

MARYLAND COALS.

224. Semibituminous coal delivered to Fort Howard, Md., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 2.5 per cent moisture, "as received"; 7.5 per cent ash, 14,500 B. t. u., "dry coal." Price, $4.35 per ton.

225. Semibituminous coal delivered to the third lighthouse district, Tompkinsville, N. Y., Bureau of Lighthouses, Department of Commerce, 1913–14. Contract guaranties: 22 per cent volatile matter, 2 per cent sulphur, 7 per cent ash, 14,000 B. t. u., "dry coal." Price, $4.45 per ton.

226. Semibituminous coal delivered to the Government Hospital for the Insane, Washington, D. C., Department of the Interior, 1913–14. Contract guaranties: 1.25 per cent moisture, "as received"; 8 per cent ash, 14,000 B. t. u., "dry coal." Price $3.35 per ton.

227. Semibituminous coal delivered to Fort Washington, Md., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 7 per cent ash, "dry coal"; 14,250 B. t. u., "as received." Price, $4.09 per ton.

228. Semibituminous coal delivered to the naval hospital, Washington, D. C., Navy Department, 1912–13. Contract guaranties: 3 per cent moisture, "as received"; 19.5 per cent volatile matter, 1.1 per cent sulphur, 7.5 per cent ash, 14,300 B. t. u., "dry coal." Price, $3.55 per ton.

229. Semibituminous coal delivered to the Columbia Institution for the Deaf, Kendall Green, D. C., 1912–13. Contract guaranties and price same as No. 228.

230. Semibituminous coal delivered to the sewage pumping station, Washington, D. C., 1912–13. Contract guaranties: 3 per cent moisture, "as received"; 7.5 per cent ash, 14,400 B. t. u., "dry coal." Price, $3.17 per ton.

231. Semibituminous coal delivered to the naval hospital, Washington, D. C., Navy Department, 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 19.5 per cent volatile matter, 1.1 per cent sulphur, 8 per cent ash, 14,250 B. t. u., "dry coal." Price, $3.70 per ton.

232. Semibituminous coal delivered to the sewage pumping station, Washington, D. C., 1913–14. Contract guaranties same as No. 231. Price, $3.32 per ton.

233. Semibituminous coal delivered to the Weather Bureau, Bluemont, Va., Department of Agriculture, 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 19.5 per cent volatile matter, 1.1 per cent sulphur, 7 per cent ash, 14,350 B. t. u., "dry coal." Price, $4 per ton.

234. Semibituminous coal delivered to the Columbia Institution for the Deaf, Washington, D. C., 1913–14. Contract guaranties same as No. 231. Price, $3.70 per ton.

235. Semibituminous coal delivered to the navy yard at Philadelphia, Pa., Navy Department, 1914–15. Contract guaranties: 1.50 per cent moisture, "as received"; 19.29 per cent volatile matter, 1 per cent sulphur, 7.61 per cent ash, 14,533 B. t. u., "dry coal." Price, $2.92 per ton f. o. b. vessels at coal piers, $3.09 per ton f. o. b. barges alongside navy yard, and $3.25 per ton f. o. b. cars at navy yard.

236. Semibituminous coal delivered to the United States Naval Academy, Annapolis, Md., Navy Department, 1914–15. Contract guaranties same as No. 235. Price, $3.15 per ton at wharf, Naval Academy, and $3.65 per ton stored aboard or ashore.

237. Semibituminous coal delivered to the sewage pumping station, Washington, D. C., 1914–15. Contract guaranties: 3 per cent moisture, "as received"; 19.50 per cent volatile matter, 1.10 per cent sulphur, 8 per cent ash, 14,280 B. t. u., "dry coal." Price, $3.40 per ton.

238. Semibituminous coal delivered to the naval hospital, Washington, D. C., Navy Department, 1914–15. Price, $3.87 per ton.

239. Semibituminous coal delivered to the District of Columbia Workhouse, Occoquan, Va., 1914–15. Contract guaranties: 3 per cent moisture, "as received"; 19.50 per cent volatile matter, 1.10 per cent sulphur, 8 per cent ash, 14,250 B. t. u., "dry coal." Price, $3.49 per ton.

240. Semibituminous coal delivered to the Columbia Institute for the Deaf, Washington, D. C., 1914–15. Contract guaranties same as No. 239. Price, $3.70 per ton.

241. Semibituminous coal delivered to the United States Navy, Curtis Bay, Md., Navy Department, 1914–15. Contract guaranties: 1.50 per cent moisture, "as received"; 19.29 per cent volatile matter, 1 per cent sulphur, 7.61 per cent ash, 14,533 B. t. u., "dry coal." Price, $2.85 per ton.

242. Semibituminous coal delivered to the Naval Academy, Annapolis, Md., Navy Department, 1913–14. Contract guaranties: 2 per cent moisture, "as received"; 19 per cent volatile matter, 1.25 per cent sulphur, 8 per cent ash, 14,400 B. t. u., "dry coal." Price, $3.01 per ton.

243. Semibituminous coal delivered to the naval engineering experiment station, Annapolis, Md., Navy Department, 1913–14. Contract guaranties same as No. 242. Price, $3.03 per ton.

244. Semibituminous coal delivered to the Government Hospital for the Insane, Washington, D. C., Department of the Interior, 1914–15. Contract guaranties: 2.5 per cent moisture, "as received"; 19 per cent volatile matter, 1.25 per cent sulphur, 7 per cent ash, 14,500 B. t. u., "dry coal." Price, $3.06 per ton.

245. Semibituminous coal delivered to the United States Naval Academy, Annapolis, Md., Navy Department, 1914–15. Contract guaranties: 2.5 per cent moisture, "as received"; 19 per cent volatile matter, 1.25 per cent sulphur, 8 per cent ash, 14,400 B. t. u., "dry coal." Price, $3.04 per ton by water, $3.05 per ton by rail.

246. Semibituminous coal delivered to the fifth lighthouse district, Baltimore, Md., Bureau of Lighthouses, Department of Commerce, 1914–15. Contract guaranties: 2.5 per cent moisture, "as received"; 19 per cent volatile matter, 1 per cent sulphur, 7 per cent ash, 14,400 B. t. u., "dry coal." Price, $2.94 per ton.

247. Semibituminous coal delivered to the naval hospital, Washington, D. C., Navy Department, 1910–11. Contract guaranties: 7 per cent ash, "dry coal"; 14,200 B. t. u., "as received." Price, $3.37 per ton.

248. Semibituminous coal delivered to Fort Constitution, N. H., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 9 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $4.35 per ton.

249. Semibituminous coal delivered to Fort Strong, Mass., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 8 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $5.05 per ton.

250. Semibituminous coal delivered to Fort Warren, Mass., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 2 per cent moisture,

"as received"; 22 per cent volatile matter, 2 per cent sulphur, 8 per cent ash, 14,200 B. t. u., "dry coal." Price, $5.29 per ton.

251. Semibituminous coal delivered to Fort Strong, Mass., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 2 per cent moisture, "as received"; 8 per cent ash, 14,200 B. t. u., "dry coal." Price, $5.29 per ton.

252. Semibituminous coal delivered to Fort Constitution, N. H. (for vessels), Quartermaster Corps, War Department, 1913–14. Contract guaranties: 2 per cent moisture, "as received"; 8.5 per cent ash, 14,100 B. t. u., "dry coal." Price, $4.70 per ton delivered at Portsmouth, N. H.

253. Semibituminous coal delivered to the Government Hospital for the Insane, Washington, D. C., Department of the Interior, 1912–13. Contract guaranties: 3 per cent moisture, "as received"; 10 per cent ash, 14,000 B. t. u., "dry coal." Price, $2.75 per ton.

254. Semibituminous coal delivered to the Government Hospital for the Insane, Washington, D. C., Department of the Interior, 1913–14. Contract guaranties: 2 per cent moisture, "as received"; 7 per cent ash, 14,000 B. t. u., "dry coal." Price, $2.90 per ton.

MICHIGAN COALS.

255. Bituminous coal delivered to the United States Indian school, Mount Pleasant, Mich., Office of Indian Affairs, Department of the Interior, 1910–11. Contract guaranties: 8.5 per cent ash "dry coal"; 11,675 B. t. u., "as received." Price $3.29 per ton (2,000 pounds).

MISSOURI COALS.

256. Bituminous coal delivered to Fort Crook, Nebr., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 14 per cent ash, "dry coal"; 10,600 B. t. u., "as received." Price, $4.25 per ton.

MONTANA COALS.

257. Subbituminous coal delivered to the post office, Helena, Mont., Treasury Department, 1910–11. Contract guaranties: 10 per cent ash, "dry coal"; 10,940 B. t. u., "as received." Price, $3.36 per ton.

258. Subbituminous coal delivered to Fort Missoula, Mont., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 10.49 per cent ash, "dry coal"; 10,922 B. t. u., "as received." Price, $2.80 and $3.08 per ton f. o. b. mines (according to months of delivery).

259. Subbituminous coal delivered to Fort William Henry Harrison, Mont., Quartermaster Corps, War Department, 1911–12. Contract guaranties same as No. 258. Price, $2.80 and $3.08 f. o. b. mines (according to months of delivery).

260. Subbituminous coal delivered to Fort Missoula, Mont., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 8.62 per cent moisture, "as received"; 8.25 per cent ash, 12,980 B. t. u., "dry coal." Price, $3.696 and $3.976 per ton (according to months of delivery).

261. Subbituminous coal delivered to Fort Yellowstone, Wyo., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 8.62 per cent moisture, "as received"; 8.25 per cent ash, 12,980 B. t. u., "dry coal." Price, $2.856 per ton for July, August, and March to June inclusive, and $3.136 per ton for September to February, inclusive, f. o. b. mines.

262. Subbituminous coal delivered to Fort Yellowstone, Wyo., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 9.68 per cent moisture, "as received"; 9.55 per cent ash, 12,980 B. t. u., "dry coal." Price, $3.22 per ton for July, August, and March to June, inclusive, and $3.52 per ton for September to February, inclusive, f. o. b. mines.

263. Subbituminous coal delivered to Fort William Henry Harrison, Mont., Quartermaster Corps, War Department, 1912–13. Contract guaranties and prices same as No. 261.

264. Subbituminous coal delivered to Fort Missoula, Mont., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 9.68 per cent moisture, "as received"; 9.55 per cent ash, 12,980 B. t. u., "dry coal." Price, $4.06 per ton in July, August, and March to June inclusive, and $4.36 per ton for September to February, inclusive.

265. Subbituminous coal delivered to Fort Missoula, Mont., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 9.68 per cent moisture, "as received"; 43.70 per cent volatile matter, 1.53 per cent sulphur, 10.10 per cent ash, 12,500 B. t. u., "dry coal." Price, $3.36 per ton in July and August, 1914, and June, 1915, and $3.64 per ton in September, 1914, and February, 1915.

266. Subbituminous coal delivered to the post office, Helena, Mont., Treasury Department, 1911–12. Contract guaranties: 9.9 per cent ash, "dry coal"; 10,960 B. t. u., "as received." Price, $3.10 per ton.

267. Subbituminous coal delivered to Fort George Wright, Wash., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 7.5 per cent ash, "dry coal"; 11,500 B. t. u., "as received." Price, $3.50 per ton f. o. b. Washoe, Mont.

268. Bituminous coal delivered to the post office, Helena, Mont., Treasury Department, 1910–11. Contract guaranties: 14.7 per cent ash, "dry coal"; 11,190 B. t. u., "as received." Price, $5.90 per ton.

269. Bituminous coal delivered to the Fort Peck Indian School, Poplar, Mont., Office of Indian Affairs, Department of the Interior, 1910–11. Contract guaranties: 13.47 per cent ash, "dry coal"; 11,675 B. t. u., "as received." Price, $6.25 per ton (2,000 pounds).

270. Bituminous coal delivered to the post office, Helena, Mont., Treasury Department, 1911–12. Contract guaranties: 15 per cent ash, "dry coal," and 10,600 B. t. u., "as received." Price, $5.75 per ton.

271. Bituminous coal delivered to Fort Yellowstone, Wyo., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 12 per cent ash, "dry coal"; 10,500 B. t. u., "as received." Price, $6.60 per ton.

NEW MEXICO COALS.

272. Bituminous coal delivered to the Mescalero Indian Agency, Mescalero, N. Mex., Office of Indian Affairs, Department of the Interior, 1910–11. Contract guaranties: 12 per cent ash, "dry coal"; 13,000 B. t. u., "as received." Price, $5.30 per ton (2,000 pounds).

273. Bituminous coal delivered to Fort Huachuca, Ariz., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 13 per cent ash, "dry coal"; 12,750 B. t. u., "as received." Price, $12.95 per ton.

274. Bituminous coal delivered to Fort Bayard, N. Mex., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 13 per cent ash, "dry coal"; 12,500 B. t. u., "as received." Price, $10 per ton.

275. Bituminous coal delivered to Fort Bayard, N. Mex., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 2 per cent moisture,

"as received"; 13 per cent ash, 12,750 B. t. u., "dry coal." Price, $8.30 per ton.

276. Bituminous coal delivered to Fort Huachuca, Ariz., Quartermaster Corps, War Department, 1912–13. Price, $12 per ton.

277. Bituminous coal delivered to Fort Bayard, N. Mex., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 2 per cent moisture, "as received"; 37.95 per cent volatile matter, 0.75 per cent sulphur, 13 per cent ash, 13,000 B. t. u., "dry coal." Price, $7.35 and $7.64 per ton ($7.35 per 1,000 tons in storage; rest at $7.64).

278. Bituminous coal delivered to Fort Huachuca, Ariz., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 2 per cent moisture, "as received"; 34 per cent volatile matter, 0.70 per cent sulphur, 13 per cent ash, 12,750 B. t. u., "dry coal." Price, $10.18 per ton.

279. Bituminous coal delivered to Fort Huachuca, Ariz., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 2 per cent moisture, "as received"; 34 per cent volatile matter, 0.70 per cent sulphur, 15 per cent ash, 12,250 B. t. u., "dry coal." Price, $9.46 per ton.

280. Bituminous coal delivered to Fort Bliss, Tex., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 8 per cent ash, "dry coal"; 13,800 B. t. u., "as received." Price, $6.496 per ton.

281. Bituminous coal delivered to Fort Bliss, Tex., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 2 per cent moisture, "as received"; 8 per cent ash, 13,800 B. t. u., "dry coal." Price, $6.72 per ton.

282. Bituminous coal delivered to Fort Bliss, Tex., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 1.5 per cent moisture, "as received"; 35 per cent volatile matter, 0.5 per cent sulphur, 12 per cent ash, 12,750 B. t. u., "dry coal." Price, $6.104 per ton.

283. Subbituminous coal delivered to Fort Rosecrans, Cal., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 8 per cent ash, "dry coal"; 12,750 B. t. u., "as received." Price, $14.25 per ton.

284. Subbituminous coal delivered to Whipple Barracks, Ariz., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 9.26 per cent ash, "dry coal"; 12,254 B. t. u., "as received." Price, $8.75 per ton.

285. Subbituminous coal delivered to Whipple Barracks, Ariz., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 10 per cent moisture, "as received"; 9 per cent ash, 11,125 B. t. u., "dry coal." Price, $3.82 per ton f. o. b. Gallup, N. Mex.

286. Bituminous coal delivered to the Jicarilla Indian school, Dulce, N. Mex., Office of Indian Affairs, Department of the Interior, 1910–11. Contract guaranties: 6 per cent ash, "dry coal"; 13,500 B. t. u., "as received." Price, $4.65 per ton (2,000 pounds).

287. Anthracite coal delivered to Fort Bayard, N. Mex., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 8.75 per cent ash, "dry coal"; 12,900 B. t. u., "as received." Price, $16.32 per ton.

288. Anthracite coal delivered to Fort Bayard, N. Mex., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 10 per cent ash, "dry coal." Price, $14 per ton.

289. Anthracite coal delivered to Fort Bayard, N. Mex., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 11 per cent ash, "dry coal." Price, $13 per ton.

290. Anthracite coal delivered to Fort Bayard, N. Mex., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 10 per cent ash, 13,000 B. t. u., "dry coal." Price, $12.40 per ton.

291. Anthracite coal delivered to Fort Bayard, N. Mex., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 3 per cent moisture, "as received"; 6.1 per cent volatile matter, 0.7 per cent sulphur, 10 per cent ash, 13,250 B. t. u., "dry coal." Price, $12.50 per ton.

NORTH DAKOTA COAL.

292. Lignite delivered to the United States Reclamation Service, Williston, N. Dak., Department of the Interior, 1914–15.

OHIO COALS.

293. Bituminous coal delivered to the Northwestern Branch of the National Home for Disabled Volunteer Soldiers, National Home, Wis., 1911–12. Contract guaranties: 8 per cent ash, "dry coal"; 13,095 B. t. u., "as received." Price, $3.95 per ton (2,000 pounds).

294. Bituminous coal delivered to the Northwestern Branch of the National Home for Disabled Volunteer Soldiers, National Home, Wis., 1912–13. Contract guaranties: 3.5 per cent moisture, "as received"; 8 per cent ash, 13,400 B. t. u., "dry coal." Price, $3.95 per ton (2,000 pounds).

295. Bituminous coal delivered to the Northwestern Branch of the National Home for Disabled Volunteer Soldiers, National Home, Wis., 1913–14. Contract guaranties: 3.5 per cent moisture, "as received"; 32 per cent volatile matter, 1.75 per cent sulphur, 8 per cent ash, 13,400 B. t. u., "dry coal." Price, $3.95 per ton (2,000 pounds).

296. Bituminous coal delivered to the post-office building, Toledo, Ohio, Treasury Department, 1913–14. Contract guaranties: 3.5 per cent moisture, "as received"; 44.1 per cent volatile matter, 3.35 per cent sulphur, 9.4 per cent ash, "dry coal"; 13,260 B. t. u., "as received." Price, $3.10 per ton.

297. Bituminous coal delivered to Columbus Barracks, Ohio, Quartermaster Corps, War Department, 1911–12. Contract guaranties: 9.35 per cent ash, "dry coal"; 11,300 B. t. u., "as received." Price, $2.45 per ton.

298. Bituminous coal delivered to Columbus Barracks, Ohio, Quartermaster Corps, War Department, 1912–13. Contract guaranties: 6.21 per cent moisture, "as received"; 7.64 per cent ash, 12,500 B. t. u., "dry coal." Price, $3.15 per ton.

299. Bituminous coal delivered to Columbus Barracks, Ohio, Quartermaster Corps, War Department, 1913–14. Contract guaranties: 6.95 per cent moisture, "as received"; 40 per cent volatile matter, 3.25 per cent sulphur, 8.5 per cent ash, 12,500 B. t. u., "dry coal." Price, $3.30 per ton.

300. Bituminous coal delivered to the customhouse and post office, Toledo, Ohio, Treasury Department, 1907–8. Contract guaranties: 6.91 per cent ash, "dry coal"; 11,475 B. t. u., "as received." Price, $4.12 per ton.

OKLAHOMA COALS.

301. Bituminous coal delivered to the remount depot, Fort Reno, Okla., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 7 per cent ash, "dry coal"; 13,600 B. t. u., "as received." Price, $4.35 per ton.

302. Bituminous coal delivered to Fort Reno, Okla., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 3 per cent moisture, "as received"; 10 per cent ash, 13,000 B. t. u., "dry coal." Price, $4.20 per ton.

303. Bituminous coal delivered to the remount depot, Fort Reno, Okla., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 10 per cent ash, "dry coal"; 12,500 B. t. u., "as received." Price, $5.30 per ton.

304. Bituminous coal delivered to the remount depot, Fort Reno, Okla., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 7 per cent moisture, "as received"; 35 per cent volatile matter, 5 per cent sulphur, 8 per cent ash, 12,500 B. t. u., "dry coal." Price, $5.20 per ton.

305. Bituminous coal delivered to the remount depot, Fort Reno, Okla., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 7 per cent moisture, "as received"; 35 per cent volatile matter, 5 per cent sulphur, 9 per cent ash, and 12,500 B. t. u., "dry coal." Price, $3.85 per ton.

306. Bituminous coal delivered to the remount depot, Fort Reno, Okla., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 6 per cent moisture, "as received"; 13 per cent ash, 12,500 B. t. u., "dry coal." Price, $5.48 per ton.

307. Bituminous coal delivered to Fort Sill, Okla., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 6 per cent moisture, "as received"; 35 per cent volatile matter, 2.5 per cent sulphur, 13 per cent ash, 12,500 B. t. u., "dry coal." Price, $4.59 per ton.

308. Bituminous coal delivered to Fort Sill, Okla., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 9.1 per cent ash, "dry coal"; 12,610 B. t. u., "as received." Price, $5.90 per ton.

309. Bituminous coal delivered to Fort Sill, Okla., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 35 per cent volatile matter, 2 per cent sulphur, 10 per cent ash, 13,500 B. t. u., "dry coal." Price, $5.95 per ton.

PENNSYLVANIA COALS.

310. Bituminous coal delivered to the United States courthouse and post office building, Louisville, Ky., Treasury Department, 1908–9. Contract guaranties: 6 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $2.65 per ton.

311. Bituminous coal delivered to the United States engineer office, Grand Rapids, Mich., War Department, 1914–15. Contract guaranties: 1.15 per cent moisture, "as received"; 35 per cent volatile matter, 0.98 per cent sulphur, 5.7 per cent ash, 14,100 B. t. u., "dry coal." Price, per ton (2,000 pounds), $3.40 for delivery at St. Joseph, South Haven, Holland, Grand Haven, and Muskegon, Mich.; $3.60 at Ludington, Manistee, and Frankfort; and $3.75 at Charlevoix.

312. Bituminous coal delivered to the post office, Minneapolis, Minn., Treasury Department, 1914–15. Contract guaranties: 35 per cent volatile matter, 2 per cent sulphur, 8 per cent ash, "dry coal"; 13,000 B. t. u., "as received." Price, $4.35 per ton.

313. Bituminous coal delivered to the post office, Buffalo, N. Y., Treasury Department, 1913–14. Price, $3.05 per ton.

314. Bituminous coal delivered to the post office, Buffalo, N. Y., Treasury Department, 1914–15. Price, $3.05 per ton.

315. Semibituminous coal delivered to the mint building, Philadelphia, Pa., Treasury Department, 1914–15. Contract guaranties: 2.5 per cent moisture, "as received"; 20 per cent volatile matter, 1.5 per cent sulphur, 5 per cent ash, 14,250 B. t. u., "dry coal." Price, $3.24 per ton.

316. Semibituminous coal delivered to the post office, Philadelphia, Pa., Treasury Department, 1914–15. Contract guaranties: 22 per cent volatile matter, 1.5 per cent sulphur, 6 per cent ash, "dry coal"; 14,200 B. t. u., "as received." Price, $3.44 per ton.

317. Semibituminous coal delivered to the United States appraiser's warehouse, New York, N. Y., Treasury Department, 1909–10. Contract guaranties: 6 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3.35 per ton.

318. Semibituminous coal delivered to the United States courthouse and post office, New York, N. Y., Treasury Department, 1909–10. Contract guaranties: 6 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3.37 per ton.

319. Bituminous coal delivered to the third lighthouse district, Tompkinsville, N. Y., Bureau of Lighthouses, Department of Commerce, 1913–14. Contract guaranties: 22 per cent volatile matter, 2 per cent sulphur, 9 per cent ash, 14,000 B. t. u., "dry coal." Price, $2.85 per ton.

320. Semibituminous coal delivered to the Panama Railroad Co., New York, N. Y., 1912–13. Contract guaranty: 14,200 B. t. u., "as received." Price, $2.89 per ton.

321 and 322. Semibituminous coal delivered to the Panama Railroad Co., New York, N. Y. Contract guaranty: 14,400 B. t. u., "dry coal." Price, $3.02 per ton. No. 321 was delivered in 1913–14, and No. 322 in 1914–15.

323. Semibituminous coal delivered to the navy yard at Philadelphia, Pa., Navy Department, 1914–15. Contract guaranties: 2.26 per cent moisture, "as received"; 21.82 per cent volatile matter, 1.22 per cent sulphur, 6.37 per cent ash, 14,567 B. t. u., "dry coal." Price, $2.85 per ton f. o. b. vessels at coal piers, and $2.95 per ton f. o. b. barges alongside navy yard.

324. Semibituminous coal delivered to the navy yard at New York, N. Y., Navy Department, 1914–15. Contract guaranties same as No. 323. Price, $3.25 per ton f. o. b. barges alongside navy yard.

325. Semibituminous coal delivered to the Naval Academy, Annapolis, Md., Navy Department, 1911–12. Contract guaranties: 6 per cent ash, 14,500 B. t. u., "as received." Price, $2.66 per ton.

326. Semibituminous coal delivered to the navy yard at Philadelphia, Pa., Navy Department, 1911–12. Contract guaranties same as No. 325. Price, $2.45 per ton.

327, 328, 329. Semibituminous coal delivered to the Frankford Arsenal, Philadelphia, Pa., War Department. Contract guaranties: 8 per cent ash, 14,200 B. t. u., "dry coal." No. 327 delivered in 1912–13; price, $2.80 per ton; No. 328 in 1913–14, price, $2.85; and No. 329 in 1914–15, price, $2.85.

330. Semibituminous coal delivered to the United States engineer office, Philadelphia, Pa., War Department, 1910–11. Contract guaranties: 20 per cent volatile matter, 1.5 per cent sulphur, 8.5 per cent ash, "dry coal"; 14,100 B. t. u., "as received." Price, $3.30 per ton in vessels and $2.90 per ton at piers.

331. Semibituminous coal delivered to the United States engineer office, Philadelphia, Pa., War Department, 1911–12. Contract guaranties: 14,300 B. t. u., "as received." Price, $2.90 per ton in vessels and $2.75 per ton in scows.

332. Semibituminous coal delivered to the United States engineer office, Philadelphia, Pa., War Department, 1912–13. Contract guaranties: 13,880 B. t. u., "dry coal." Price, $2.75, $2.90, and $3.19 per ton (according to method of delivery).

333. Semibituminous coal delivered to the Eastern Branch of the National Home for Disabled Volunteer Soldiers, National Soldiers' Home, Me., 1913–14. Contract guaranties: 2 per cent moisture, "as received"; 20 to 21 per cent volatile matter, 1.5 per cent sulphur, 7 per cent ash, 14,750 B. t. u., "dry coal." Price, $4.03 per ton.

334. Semibituminous coal delivered to the United States engineer office, Philadelphia, Pa., War Department, 1913–14. Contract guaranties: 1.5 per cent moisture, "as received"; 6 per cent ash, 14,600 B. t. u., "dry coal." Price, $3.27, $2.83, and $2.98 per ton (according to method of delivery).

335. Bituminous coal delivered to the navy yard at Philadelphia, Pa., Navy Department, 1914–15. Contract guaranties: 1.5 per cent moisture, "as received"; 25 per cent volatile matter, 1 per cent sulphur, 7 per cent ash, 14,545 B. t. u., "dry coal." Price, $2.79 per ton.

336. Bituminous coal delivered to the navy yard at Brooklyn, N. Y., Navy Department, 1914–15. Contract guaranties: 1 per cent moisture, "as received"; 24 per cent volatile matter, 1 per cent sulphur, 6.5 per cent ash, 14,500 B. t. u., "dry coal." Price, $3.05 per ton.

337. Semibituminous coal delivered to the United States engineer office, New York, N. Y., War Department, 1914–15. Contract guaranties: 3 per cent moisture, "as received"; 18 per cent volatile matter, 1.5 per cent sulphur, 8 per cent ash, 14,400 B. t. u., "dry coal." Price, $3.43 per ton.

338. Semibituminous coal delivered to the post office, Philadelphia, Pa., Treasury Department, 1913–14. Contract guaranties: 7 per cent ash, "dry coal"; 14,600 B. t. u., "as received." Price, $3.35 per ton.

339. Semibituminous coal delivered to the Springfield Armory, Springfield, Mass., War Department, 1913–14. Contract guaranties: 8 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $4.60 per ton at hill shops and $4.25 per ton at water shops.

340. Semibituminous coal delivered to the Frankford Arsenal, Philadelphia, Pa., War Department, 1909–10. Contract guaranties: 5 per cent ash, "dry coal"; 14,200 B. t. u., "as received." Price, $2.60 per ton.

341. Semibituminous coal delivered to the customhouse, Baltimore, Md., Treasury Department, 1910–11. Contract guaranties: 5 per cent ash, "dry coal"; 14,300 B. t. u., "as received." Price, $3.13 per ton.

342. Semibituminous coal delivered to the United States courthouse and post office, Baltimore, Md., Treasury Department, 1910–11. Contract guaranties and price same as No. 341.

343. Semibituminous coal delivered to the Frankford Arsenal, Philadelphia, Pa., War Department, 1910–11. Contract guaranties same as No. 341. Price, $2.69 per ton.

344. Semibituminous coal delivered to the mint building, Philadelphia, Pa., Treasury Department, 1910–11. Contract guaranties same as No. 341. Price, $3.09 per ton.

345. Semibituminous coal delivered to the United States courthouse and post office, Philadelphia, Pa., Treasury Department, 1910–11. Contract guaranties same as No. 341. Price, $3.22 per ton.

346. Semibituminous coal delivered to the Naval Academy, Annapolis, Md., Navy Department, 1910–11. Contract guaranties same as No. 341. Price, $2.75 per ton.

347. Semibituminous coal delivered to the United States courthouse and post office, Baltimore, Md., Treasury Department, 1911–12. Contract guaranties same as No. 341. Price, $3.10 per ton.

348. Semibituminous coal delivered to Frankford Arsenal, Philadelphia, Pa., War Department, 1911–12. Contract guaranties same as No. 341. Price, $2.67 per ton.

349. Semibituminous coal delivered to the mint building, Philadelphia, Pa., Treasury Department, 1911–12. Contract guaranties same as No. 341. Price, $3.09 per ton.

350. Semibituminous coal delivered to the United States courthouse and post office, Philadelphia, Pa., Treasury Department, 1911–12. Contract guaranties same as No. 341. Price, $3.19 per ton.

351. Semibituminous coal delivered to the customhouse, Baltimore, Md., Treasury Department, 1911–12. Contract guaranties same as No. 341. Price, $3.10 per ton.

352. Semibituminous coal delivered to the post office, Baltimore, Md., Treasury Department, 1912–13. Contract guaranties: 22 per cent volatile matter, 1.5 per cent sulphur, 5 per cent ash, "dry coal"; 14,300 B. t. u., "as received." Price, $3.13 per ton.

353. Semibituminous coal delivered to the post office, Philadelphia, Pa., Treasury Department, 1912–13. Contract guaranties same as No. 352. Price, $3.28 per ton.

354. Semibituminous coal delivered to the post office, Baltimore, Md., Treasury Department, 1913–14. Contract guaranties: 5 per cent ash, "dry coal"; 14,300 B. t. u., "as received." Price, $3.25 per ton.

355. Semibituminous coal delivered to the United States courthouse and post office, Baltimore, Md., Treasury Department, 1914–15. Contract guaranties: 22 per cent volatile matter, 1.50 per cent sulphur, 6 per cent ash, "dry coal"; 14,300 B. t. u., "as received." Price, $3.35 per ton.

356. Semibituminous coal delivered to the mint building, Philadelphia, Pa., Treasury Department, 1912–13. Contract guaranties: 5 per cent ash, "dry coal"; 14,300 B. t. u., "as received." Price, $3.10 per ton.

357. Semibituminous coal delivered to the General Land Office, Washington, D. C., Department of the Interior, 1914–15. Contract guaranties: 2.5 per cent moisture, "as received"; 18 per cent volatile matter, 1.6 per cent sulphur, 6.5 per cent ash, 14,350 B. t. u., "dry coal." Price, $3.53 per ton.

358. Semibituminous coal delivered to the post office and subtreasury, Boston, Mass., Treasury Department, 1908–9. Contract guaranties: 7.12 per cent ash, "dry coal"; 14,257 B. t. u., "as received." Price, $4.43 per ton.

359. Semibituminous coal delivered to the third lighthouse district, Tompkinsville, N. Y., Bureau of Lighthouses, Department of Commerce, 1911–12. Contract guaranties: 7 per cent ash, "dry coal"; 14,150 B. t. u., "as received." Price, $2.63 per ton.

360. Semibituminous coal delivered to the customhouse, Albany, N. Y., Treasury Department, 1909–10. Contract guaranties: 8 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3.44 per ton.

361. Semibituminous coal delivered to the United States courthouse and post office, Albany, N. Y., Treasury Department, 1910–11. Contract guaranties same as No. 360. Price, $3.55 per ton.

362. Semibituminous coal delivered to the Springfield Armory, Springfield, Mass., War Department, 1914–15. Contract guaranties: 3.5 per cent moisture, "as received"; 18.5 per cent volatile matter, 1.1 per cent sulphur, 7.45 per cent ash, 14,522 B. t. u., "dry coal." Price, $4.40 per ton for delivery in cars at water shops, and $4.75 per ton for delivery at hill shops by teams.

363. Bituminous coal delivered to the Frankford Arsenal, Philadelphia, Pa., War Department, 1911–12. Contract guaranties: 6 per cent ash, "dry coal"; 14,300 B. t. u., "as received." Price, $2.63 per ton.

364. Semibituminous coal delivered to the Naval Academy, Annapolis, Md., Navy Department, 1910–11. Contract guaranties: 5 per cent ash, "dry coal"; 14,300 B. t. u., "as received." Price, $2.75 per ton.

365. Semibituminous coal delivered to Fort Myer, Va., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 8 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3.80 per ton.

366. Semibituminous coal delivered to the Springfield Armory, Springfield, Mass., War Department, 1910–11. Contract guaranties: 7 per cent ash, "dry coal"; 14,600 B. t. u., "as received." Price, $4.55 per ton.

367. Semibituminous coal delivered to the Eastern Branch of the National Home for Disabled Volunteer Soldiers, National Soldiers' Home, Me., 1914–15. Contract guaranties: 3.75 per cent moisture, "as received"; 19.50 per cent volatile matter, 1.5 per cent sulphur, 6.25 per cent ash, 14,700 B. t. u., "dry coal." Price, $3.92 per ton.

368. Semibituminous coal delivered to the Eastern Branch of the National Home for Disabled Volunteer Soldiers, National Soldiers' Home, Me., 1912–13. Contract guaranties: 2.25 per cent moisture, "as received"; 5.5 per cent ash, 14,700 B. t. u., "dry coal." Price, $3.87 per ton.

369. Semibituminous coal delivered to the Capitol power plant, Washington, D. C., 1914–15. Price, $2.95 per ton.

370. Semibituminous coal delivered to the mint building, Philadelphia, Pa., Treasury Department, 1909–10. Contract guaranties: 5 per cent ash, "dry coal"; 14,300 B. t. u., "as received." Price, $3.04 per ton.

371. Semibituminous coal delivered to the United States jail, Washington, D. C., Department of Justice, 1909–10. Contract guaranties: 5 per cent ash, "dry coal"; 14,250 B. t. u., "as received." Price, $3.19 per ton.

372. Semibituminous coal delivered to the Treasury Building, Washington, D. C., Treasury Department, 1909–10. Contract guaranties, same as No. 371, Price, $3.14 per ton.

373. Semibituminous coal delivered to the Winder Building, Washington, D. C., Treasury Department, 1909–10. Contract guaranties, same as No. 371. Price, $3.14 per ton.

374. Semibituminous coal delivered to the Panama Railroad Co., New York, N. Y., 1910–11. Contract guaranties: 14,200 B. t. u., "as received." Price, $2.87 per ton.

375. Semibituminous coal delivered to Fort Du Pont, Del., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 2 per cent moisture, "as received"; 6.5 per cent ash, 14,500 B. t. u., "dry coal." Price, $3.70 per ton.

376. Semibituminous coal delivered to Delaware City Wharf and Fort Du Pont, Del., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 3.5 per cent moisture, "as received"; 23.5 per cent volatile matter, 1.75 per cent sulphur, 7.5 per cent ash, 14,200 B. t. u., "dry coal." Price, $3.70 per ton.

377. Semibituminous coal delivered to the United States courthouse and post office, Baltimore, Md., Treasury Department, 1907–8. Contract guaranties: 8 per cent ash, "dry coal"; 14,200 B. t. u., "as received." Price, $3.31 per ton.

378. Semibituminous coal delivered to the United States appraiser's warehouse, New York, N. Y., Treasury Department, 1910–11. Contract guaranties: 6 per cent ash, "dry coal"; 14,100 B. t. u., "as received." Price, $3.31 per ton.

379. Semibituminous coal delivered to the United States courthouse and post office, New York, N. Y., Treasury Department, 1910–11. Contract guaranties and price same as No. 378.

380. Semibituminous coal delivered to the United States courthouse and post office, New York, N. Y., Treasury Department, 1911–12. Contract guaranties and price same as No. 378.

381. Semibituminous coal delivered to the United States courthouse and post office, Philadelphia, Pa., Treasury Department, 1908–9. Contract guaranties: 7.8 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3.30 and $3.35 per ton.

382. Semibituminous coal delivered to the mint building, Philadelphia, Pa., Treasury Department, 1908–9. Contract guaranties same as No. 381. Price, $3.14 per ton.

383. Semibituminous coal delivered to the United States appraiser's warehouse, New York, N. Y., Treasury Department, 1907–8. Contract guaranties: 7.8 per cent ash, "dry coal"; 14,474 B. t. u., "as received." Price, $3.46 per ton.

384. Semibituminous coal delivered to the United States courthouse and post office, Philadelphia, Pa., Treasury Department, 1907–8. Contract guaranties same as No. 383. Price, $3.58 per ton.

385. Semibituminous coal delivered to the depot quartermaster, New York City, N. Y., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 6.9 per cent ash, "dry coal"; 14,100 B. t. u., "as received." Price in Quartermaster's vessels, $2.795 per ton; in transports, $3.09.

386. Semibituminous coal delivered to the United States appraiser's warehouse, New York, N. Y., Treasury Department, 1911–12. Contract guaranties same as No. 385. Price, $3.27 per ton.

387. Semibituminous coal delivered to the Quartermaster Corps, New York Harbor, War Department, 1912–13. Contract guaranties: 2 per cent moisture, "as received"; 6.9 per cent ash, 14,050 B. t. u., "dry coal." Price, $2.88 per ton.

388. Semibituminous coal delivered to the New York depot and Port Liberty, N. J., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 2 per cent moisture, "as received"; 7 per cent ash, 14,050 B. t. u., "dry coal." Price, $2.94 per ton (price varies according to method of delivery).

389. Semibituminous coal delivered to the depot quartermaster, New York, N. Y., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 2.5 per cent moisture, "as received"; 20 per cent volatile matter, 1.25 per cent sulphur, 7 per cent ash, 14,050 B. t. u., "dry coal." Price, $2.98 per ton for delivery at Port Liberty, N. J., and $3.38 per ton aboard vessels in New York Harbor.

390. Semibituminous coal delivered to the United States courthouse, New York, N. Y., Treasury Department, 1914–15. Contract guaranties: 22 per cent volatile matter, 1.5 per cent sulphur, 6 per cent ash, "dry coal"; 14,150 B. t. u., "as received." Price, $3.65 per ton.

391. Semibituminous coal delivered to the United States appraiser's warehouse, New York, N. Y., Treasury Department, 1914–15. Contract guaranties same as No. 390. Price, $3.55 per ton.

392. Semibituminous coal delivered to the Frankford Arsenal, Philadelphia, Pa., War Department, 1907–8. Contract guaranties: 8 per cent ash, "dry coal"; 14,100 B. t. u., "as received." Price, $2.89 per ton.

393. Semibituminous coal delivered to the Government Hospital for the Insane, Washington, D. C., Department of the Interior, 1907–8. Contract guaranties: 8 per cent ash, "dry coal"; 14,300 B. t. u., "as received." Price, $2.89 per ton.

394. Semibituminous coal delivered to the United States courthouse and post office, Philadelphia, Pa., Treasury Department, 1909–10. Contract guaranties: 6 per cent ash, "dry coal"; 14,200 B. t. u., "as received." Price, $3.20 per ton.

395. Semibituminous coal delivered to the Watertown Arsenal, Watertown, Mass., War Department, 1910–11. Contract guaranties: 6 per cent ash, "dry coal"; 14,500 B. t. u., "as received." Price, $4.19 per ton.

396. Semibituminous coal delivered to the Frankford Arsenal, Philadelphia, Pa., War Department, 1909–10. Contract guaranties: 6 per cent ash, "dry coal"; 14,250 B. t. u., "as received." Price, $2.75 per ton.

397. Bituminous coal delivered to the post office, Buffalo, N. Y., Treasury Department, 1909–10. Contract guaranties: 5 per cent ash, "dry coal"; 14,100 B. t. u., "as received." Price, $2.84 per ton.

398. Bituminous coal delivered to the Northwestern Branch of the National Home for Disabled Volunteer Soldiers, National Soldiers' Home, Wis., 1912–13. Contract guaranties: 4 per cent moisture, "as received"; 11 per cent ash, 13,100 B. t. u., "dry coal." Price, $3 per ton (2,000 pounds).

399. Bituminous coal delivered to the United States courthouse and post office, Louisville, Ky., Treasury Department, 1909–10. Contract guaranties: 11 per cent ash, "dry coal"; 13,000 B. t. u., "as received." Price, $2.12 per ton.

400. Semibituminous coal delivered to the Panama Railroad Co., New York, N. Y., 1911–12. Contract guaranty: 14,200 B. t. u., "as received." Price, $2.87 per ton.

401. Semibituminous coal delivered to the Capitol power plant, Washington, D. C., 1911–12. Price, $3.01 per ton.

402. Bituminous coal delivered to the third lighthouse district, New York Harbor, Bureau of Lighthouses, Department of Commerce, 1914–15. Contract guaranties: 3 per cent moisture, "as received"; 22 per cent volatile matter, 2 per cent sulphur, 10 per cent ash, "dry coal"; 13,800 B. t. u., "as received." Price, $2.92 per ton.

403. Bituminous coal delivered to the engineering experiment station, United States Naval Academy, Annapolis, Md., Navy Department, 1914–15. Contract guaranties: 2.5 per cent moisture, "as received"; 26 per cent volatile matter, 1.5 per cent sulphur, 8.5 per cent ash, 14,500 B. t. u., "dry coal." Price, $3.32 per ton.

404. Bituminous coal delivered to the post office, Buffalo, N. Y., Treasury Department, 1908–9. Contract guaranties: 6.5 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3 per ton.

405. Bituminous coal delivered to the post office, Buffalo, N. Y., Treasury Department, 1910–11. Contract guaranties same as No. 404. Price, $3.14 per ton.

406. Bituminous coal delivered to the post office, Buffalo, N. Y., Treasury Department, 1912–13. Price, $3.15 per ton.

407. Bituminous coal delivered to the fourth lighthouse district, Philadelphia, Pa., Bureau of Lighthouses, Department of Commerce, 1912–13. Contract guaranties: 7 per cent ash, 14,435 B. t. u., "dry coal." Price, $3.15 per ton.

408. Semibituminous coal delivered to the naval training school, Newport, R. I., Navy Department, 1909–10. Contract guaranties: 7 per cent ash, 0.65 per cent sulphur, "dry coal"; 14,500 B. t. u., "as received." Price, $3.55 per ton.

409. Semibituminous coal delivered to Fort Greble, R. I., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 9 per cent ash, "dry coal"; 13,900 B. t. u., "as received." Price, $5.20 per ton.

410. Semibituminous coal delivered to the Panama Railroad Co., New York, N. Y., 1909–10. Contract guaranty: 14,000 B. t. u., "as received." Price, $2.64 per ton.

411. Semibituminous coal delivered to the Freedmen's Hospital and Howard University, Washington, D. C., Department of the Interior, 1908–9. Contract guaranties: 10 per cent ash, "dry coal"; 13,900 B. t. u., "as received." Price, $3.55 per ton.

412. Semibituminous coal delivered to the United States Soldiers' Home, Washington, D. C., War Department, 1908–9. Contract guaranties: 6 per cent ash, "dry coal"; 14,300 B. t. u., "as received." Price, July 1 to December 31, 1908, $3.58 per ton; January 1 to June 30, 1909, $3.29 per ton.

413. Semibituminous coal delivered to the Watertown Arsenal, Watertown, Mass., War Department, 1908–9. Contract guaranties: 8 per cent ash, "dry coal"; 14,300 B. t. u., "as received." Price, $4.21 per ton.

414. Semibituminous coal delivered to the filtration plant, Washington, D. C., War Department, 1909–10. Contract guaranties: 6 per cent ash, "dry coal" 14,300 B. t. u., "as received." Price, $3.15 per ton.

415. Semibituminous coal delivered to the United States Soldiers' Home, Washington, D. C., War Department, 1909–10. Contract guaranties same as No. 414. Price, $3.17 per ton.

416. Semibituminous coal delivered to Freedmen's Hospital, Washington, D. C., Department of the Interior, 1907–8. Contract guaranties: 10 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3.75 per ton.

417. Semibituminous coal delivered to the United States jail, Washington, D. C., Department of Justice, 1910–11. Contract guaranties: 7 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3.44 per ton.

418. Semibituminous coal delivered to the United States Indian industrial school, Carlisle, Pa., Office of Indian Affairs, Department of the Interior, 1910–11. Contract guaranties same as No. 417. Price, $2.49 per ton (2,000 pounds).

419. Semibituminous coal delivered to the filtration plant, Washington, D. C., War Department, 1910–11. Contract guaranties: 7 per cent ash, "dry coal"; 14,100 B. t. u., "as received." Price, $3.29 per ton.

420. Semibituminous coal delivered to the United States Soldiers' Home, Washington, D. C., War Department, 1910–11. Contract guaranties: 7 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3.31 per ton.

421. Semibituminous coal delivered to the filtration plant, Washington, D. C., War Department, 1911–12. Contract guaranties: 7 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3.17 per ton.

422. Semibituminous coal delivered to the United States Soldiers' Home, Washington, D. C., War Department, 1911–12. Contract guaranties and price same as No. 421. Price, $3.37 per ton.

423. Semibituminous coal delivered to the National Training School for Boys, Washington, D. C., 1912–13. Contract guaranties: 2 per cent moisture, "as received"; 7 per cent ash, 14,200 B. t. u., "dry coal." Price, $3.57 per ton in vaults at school and $3.27 per ton at brickyard.

424. Semibituminous coal delivered to the filtration plant, Washington, D. C., War Department, 1912–13. Contract guaranties: 7 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3.37 per ton.

425. Semibituminous coal delivered to the National Training School for Boys, Washington, D. C., 1913–14. Contract guaranties: 1.75 per cent moisture, "as received"; 7 per cent ash, 14,200 B. t. u., "dry coal." Price, $3.67 per ton at power house and $3.82 per ton at brickyard.

426. Semibituminous coal delivered to the United States appraisers' warehouse, New York, N. Y., Treasury Department, 1908–9. Contract guaranties: 8 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3.28 per ton.

427. Semibituminous coal delivered to the United States courthouse and post office, New York, N. Y., Treasury Department, 1908–9. Contract guaranties same as No. 426. Price, $3.43 per ton.

428. Semibituminous coal delivered to the navy yard at Philadelphia, Pa., Navy Department, 1910–11. Contract guaranties: 7 per cent ash, "dry coal"; 14,100 B. t. u., "as received." Price, $2.54 per ton.

429. Semibituminous coal delivered to the power plant at Ellis Island Immigration Station, New York, N. Y., Department of Labor, 1913–14. Contract guaranties: 1 per cent moisture, "as received"; 17.5 per cent volatile matter,

1.29 per cent sulphur, 7.5 per cent ash, 14,200 B. t. u., "dry coal." Price, $3.15 per ton.

430. Semibituminous coal delivered to the United States engineer office, New York, N. Y., War Department, 1910–11. Price, $3.04 per ton.

431. Semibituminous coal delivered to the Rock Island Arsenal, Rock Island, Ill., War Department, 1910–11. Contract guaranties: 5 per cent ash, "dry coal"; 13,600 B. t. u., "as received." Price, $4.79 per ton.

432. Semibituminous coal delivered to Fort Hancock, N. J., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 8.23 per cent ash, "dry coal"; 14,240 B. t. u., "as received." Price, $3.70 per ton.

433. Semibituminous coal delivered to the United States engineer office, New York, N. Y., War Department, 1914–15. Contract guaranties: 1.75 per cent moisture, "as received"; 18 per cent volatile matter, 1 per cent sulphur, 7 per cent ash, 14,400 B. t. u., "dry coal." Price, $3.90 per ton.

434. Semibituminous coal delivered to the National Zoological Park, Washington, D. C., Smithsonian Institution, 1910–11. Contract guaranties: 7 per cent ash, "dry coal"; 14,200 B. t. u., "as received." Price, $3.85 per ton.

435. Semibituminous coal delivered to the General Land Office, Washington, D. C., Department of the Interior, 1910–11. Contract guaranties: 7 per cent ash, "dry coal"; 14,200 B. t. u., "as received." Price, $3.23 per ton.

436. Semibituminous coal delivered to the General Land Office, Washington, D. C., Department of the Interior, 1911–12. Contract guaranties: 7 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3.27 per ton.

437. Semibituminous coal delivered to the Freedmen's Hospital, Washington, D. C., Department of the Interior, 1912–13. Contract guaranties: 3 per cent moisture, "as received"; 7.5 per cent ash, 14,275 B. t. u., "dry coal." Price, $3.40 per ton.

438. Semibituminous coal delivered to the United States Soldiers' Home, Washington, D. C., War Department, 1912–13. Contract guaranties: 3 per cent moisture, "as received"; 7 per cent ash, 14,250 B. t. u., "dry coal." Price, $3.50 per ton.

439. Semibituminous coal delivered to the United States naval powder depot, Lake Denmark, N. J., Navy Department, 1912–13. Contract guaranties: 3 per cent moisture, "as received"; 17.25 per cent volatile matter, 1.60 per cent sulphur, 8 per cent ash, 14,275 B. t. u., "dry coal." Price, $3.60 per ton.

440. Semibituminous coal delivered to the United States Naval Academy, Annapolis, Md., Navy Department, 1912–13. Contract guaranties same as No. 439. Price $2.90 at sea wall, Naval Academy, and $3.40 per ton at engineering experiment station.

441. Semibituminous coal delivered to the District of Columbia pumping station, Washington, D. C., 1912–13. Contract guaranties: 3 per cent moisture, "as received"; 7.5 per cent ash, 14,275 B. t. u., "dry coal." Price, $3.27 per ton.

442. Semibituminous coal delivered to the General Land Office, Washington, D. C., Department of the Interior, 1912–13. Contract guaranties: 3 per cent moisture, "as received"; 7.5 per cent ash, 14,275 B. t. u., "dry coal." Price, $3.32 per ton.

443. Semibituminous coal delivered to the United States Soldiers' Home, Washington, D. C., War Department, 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 17.25 per cent volatile matter, 1.6 per cent sulphur, 8.5 per cent ash, 14,100 B. t. u., "dry coal." Price, $3.60 per ton.

444. Semibituminous coal delivered to the National Zoological Park, Washington, D. C., Smithsonian Institution, 1913–14. Contract guaranties same as No. 443. Price, $4.10 per ton.

445. Semibituminous coal delivered to the Freedmen's Hospital, Washington, D. C., Department of the Interior, 1913–14. Contract guaranties same as No. 443. Price, $3.55 per ton.

446. Semibituminous coal delivered to the filtration plant, Washington, D. C., War Department, 1913–14. Contract guaranties: 3.5 per cent moisture, "as received"; 17.25 per cent volatile matter, 1.6 per cent sulphur, 8.5 per cent ash, 14,000 B. t. u., "dry coal." Price, $3.14 per ton (2,000 pounds).

447. Semibituminous coal delivered to the General Land Office, Washington, D. C., Department of the Interior, 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 17.25 per cent volatile matter, 1.6 per cent sulphur, 8.5 per cent ash, 14,100 B. t. u., "dry coal." Price, $3.50 per ton.

448. Semibituminous coal delivered to the District of Columbia pumping station, Washington, D. C., 1913–14. Contract guaranties same as No. 447. Price, $3.35 per ton.

449. Semibituminous coal delivered to the United States Soldiers' Home, Washington, D. C., War Department, 1914–15. Contract guaranties: 3 per cent moisture, "as received"; 19.5 per cent volatile matter, 1.6 per cent sulphur, 9 per cent ash, 14,100 B. t. u., "dry coal." Price, $3.65 per ton.

450. Semibituminous coal delivered to the District of Columbia pumping station, Washington, D. C., 1914–15. Contract guaranties: 3 per cent moisture, "as received"; 17.25 per cent volatile matter, 1.6 per cent sulphur, 9 per cent ash, 14,100 B. t. u., "dry coal." Price, $3.52 per ton.

451. Semibituminous coal delivered to the filtration plant, Washington, D. C., War Department, 1914–15. Contract guaranties: 2.5 per cent moisture, "as received"; 17.25 per cent volatile matter, 1.5 per cent sulphur, 8.5 per cent ash, 14,100 B. t. u., "dry coal." Price $3.21 per ton.

452. Semibituminous coal delivered to Freedmen's Hospital, Washington, D. C., Department of the Interior, 1914–15. Contract guaranties same as No. 450. Price, $3.58 per ton.

453. Semibituminous coal delivered to the National Training School for Boys, Washington, D. C., 1914–15. Contract guaranties: 2.5 per cent moisture, "as received"; 17.25 per cent volatile matter, 1.6 per cent sulphur, 10.3 per cent ash, 13,950 B. t. u., "dry coal." Price, $3.65 per ton for delivery at power plant,, and $3.80 per ton at brickyard.

454. Semibituminous coal delivered to the customhouse, Toledo, Ohio, Treasury Department, 1910–11. Contract guaranties: 6 per cent ash, "dry coal"; 14,300 B. t. u., "as received." Price, $3.62 per ton.

455. Semibituminous coal delivered to Fort Totten, N. Y., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 10 per cent ash, "dry coal'"; 13,750 B. t. u., "as received." Price, $2.90 per ton.

456. Semibituminous coal delivered to the fifth lighthouse district, Baltimore, Md., Bureau of Lighthouses, Department of Commerce, 1911–12. Price, $3.47 per ton at Washington, N. C., $3.52 per ton at Long Point, N. C., and $3.44 per ton at Point Lookout, Md.

457. Semibituminous coal delivered to Fort H. G. Wright, N. Y., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 9.5 per cent ash, "dry coal"; 13,650 B. t. u., "as received." Price, $3.75 per ton for delivery at New London, Conn.

458. Semibituminous coal delivered to Fort Du Pont, Del., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 10 per cent ash, "dry coal"; 13,750 B. t. u., "as received." Price, $2.95 per ton.

459. Semibituminous coal delivered to the third lighthouse district, Tompkinsville, N. Y., Bureau of Lighthouses, Department of Commerce, 1912–13.

Contract guaranties: 22 per cent volatile matter, 2 per cent sulphur, 9.5 per cent ash, 13,400 B. t. u., "dry coal." Price, $3.20 per ton for delivery at New London, Conn.

460. Semibituminous coal delivered to the third lighthouse district, Tompkinsville, N. Y., Bureau of Lighthouses, Department of Commerce, 1913–14. Contract guaranties same as No. 459. Price, $3.60 per ton for delivery at New London, Conn.

461. Semibituminous coal delivered to Fort H. G. Wright, N. Y., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 4 per cent moisture, "as received"; 12 per cent ash, 13,800 B. t. u., "dry coal." Price $3.95 per ton.

462. Semibituminous coal delivered to Fort H. G. Wright, N. Y., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 4 per cent moisture, "as received"; 12 per cent ash, and 13,600 B. t. u., "dry coal." Price, $4.05 per ton for delivery at New London, Conn.

463. Semibituminous coal delivered to the third lighthouse district, Tompkinsville, N. Y., Bureau of Lighthouses, Department of Commerce, 1914–15. Contract guaranties: 4 per cent moisture, "as received"; 22 per cent volatile matter, 2 per cent sulphur, 9.5 per cent ash, "dry coal"; 13,400 B. t. u., "as received." Price $3.70 per ton for delivery at New London, Conn.

464. Semibituminous coal delivered to the Government Hospital for the Insane, Washington, D. C., Department of the Interior, 1912–13. Contract guaranties: 1.25 per cent moisture, "as received"; 8 per cent ash. 14,000 B. t. u., "dry coal." Price, $2.65 per ton.

465. Bituminous coal delivered to the post office, Minneapolis, Minn., Treasury Department, 1909–10. Contract guaranties: 6 per cent ash, "dry coal"; 14,200 B. t. u., "as received." Price, $5 per ton.

466. Bituminous coal delivered to the United States courthouse and post office, Milwaukee, Wis., Treasury Department, 1910–11. Contract guaranties: 10.5 per cent ash, "dry coal"; 13,700 B. t. u., "as received." Price, $3.50 ton.

467. Bituminous coal delivered to the Northwestern Branch of the National Home for Disabled Volunteer Soldiers, National Home, Wis., 1911–12. Contract guaranties: 10 per cent ash, "dry coal"; 12,800 B. t. u., "as received." Price, $2.75 per ton (2,000 pounds).

468. Bituminous coal delivered to the depot quartermaster, Jeffersonville, Ind., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 6 per cent ash, "dry coal"; 11,500 B. t. u., "as received." Price, $3.98 per ton.

469. Bituminous coal delivered to the depot quartermaster, Jeffersonville, Ind., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 2.65 per cent moisture, "as received"; 9.8 per cent ash, 13,000 B. t. u., "dry coal." Price, $4.13 per ton.

470. Bituminous coal delivered to the United States engineer office, New Orleans, La., War Department, 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 34 per cent volatile matter, 1.25 per cent sulphur, 6.5 per cent ash, 14,100 B. t. u., "dry coal." Price, $3.60 per ton (2,000 pounds) for delivery to Burrwood, Southwest Pass, and Port Eads, South Pass, Mississippi River, and New Orleans, La.

471. Bituminous coal delivered to the post office, Milwaukee, Wis., Treasury Department, 1912–13. Contract guaranties: 35 per cent volatile matter, 2 per cent sulphur, 9 per cent ash, "dry coal"; 12,825 B. t. u., "as received." Price, $3 per ton.

472. Semibituminous coal delivered to the mint building, Philadelphia, Pa., Treasury Department, 1913–14. Contract guaranties: 6 per cent ash, "dry coal"; 14,100 B. t. u., "as received." Price, $3.14 per ton.

473. Bituminous coal delivered to the United States courthouse and post office, St. Paul, Minn., Treasury Department, 1908–9. Contract guaranties: 8 per cent ash, "dry coal"; 13,300 B. t. u., "as received." Price, $5.38 per ton.

474. Bituminous coal delivered to Fort Keogh, Mont., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 5.2 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3.58 per ton f. o. b. Superior, Wis.

475. Bituminous coal delivered to Fort Snelling, Minn., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 5.2 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3.92 per ton f. o. b. at Duluth, Minn., or Superior, Wis.

476. Bituminous coal delivered to Fort Lincoln, N. Dak., Quartermaster Corps, War Department, 1911–12. Contract guaranties same as No. 475. Price, $3.92 per ton f. o. b. at Duluth, Minn., or Superior, Wis.

477. Bituminous coal delivered to Fort Lincoln, N. Dak., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 1 per cent moisture, "as received"; 4.8 per cent ash, 14,800 B. t. u., "dry coal." Price, $3.81 per ton, f. o. b. Superior, Wis.

478. Bituminous coal delivered to the eleventh lighthouse district, Detroit, Mich., Bureau of Lighthouses, Department of Commerce, 1912–13.

479. Bituminous coal delivered to Fort Keogh, Mont., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 1 per cent moisture, "as received"; 4.8 per cent ash, 14,800 B. t. u., "dry coal." Price, $3.81 per ton f. o. b. Duluth, Minn.

480. Bituminous coal delivered to Fort Keogh, Mont., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 1.62 per cent moisture, "as received"; 35.94 per cent volatile matter, 1.02 per cent sulphur, 5.93 per cent ash, 14,452 B. t. u., "dry coal." Price, $3.98 per ton f. o. b. Duluth, Minn.

481. Bituminous coal delivered to the United States courthouse and post office, Milwaukee, Wis., Treasury Department, 1911–12. Contract guaranties: 10 per cent ash, "dry coal"; 12,800 B. t. u., "as received." Price, $3.05 per ton.

482. Bituminous coal delivered to the post office, Minneapolis, Minn., Treasury Department, 1912–13. Contract guaranties: 35 per cent volatile matter, sulphur not over 2 per cent, 9 per cent ash, "dry coal"; 13,480 B. t. u., "as received." Price, $4.09 per ton.

483. Bituminous coal delivered to the Northwestern Branch of the National Home for Disabled Volunteer Soldiers, National Home, Wis., 1913–14. Contract guaranties: 4 per cent moisture, "as received"; 32 per cent volatile matter, 1.25 per cent sulphur, 9 per cent ash, 13,250 B. t. u., "dry coal." Price, $3.10 per ton (2,000 pounds).

484. Bituminous coal delivered to the post office, Milwaukee, Wis., Treasury Department, 1913–14. Contract guaranties: 9 per cent ash, "dry coal"; 13,056 B. t. u., "as received" Price, $3.28 per ton.

485. Bituminous coal delivered to the post office, Minneapolis, Minn., Treasury Department, 1913–14. Contract guaranties: 7.5 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $4.70 per ton.

486. Bituminous coal delivered to the United States courthouse and post office, Milwaukee, Wis., Treasury Department, 1908–9. Contract guaranties: 9.67 per cent ash, "dry coal"; 13,466 B. t. u., "as received." Price, $3.50 per ton.

487. Bituminous coal delivered to the United States courthouse and post office, Milwaukee, Wis., Treasury Department, 1909–10. Contract guaranties: 5.21 per cent ash, "dry coal"; 14,170 B. t. u., "as received." Price, $3.05 per ton.

488. Bituminous coal delivered to the United States post office, courthouse, and customhouse, Milwaukee, Wis., Treasury Department, 1914–15. Contract guaranties: 35 per cent volatile matter, 2 per cent sulphur, 8 per cent ash, "dry coal"; and 13,000 B. t. u., "as received." Price, $2.90 per ton.

TENNESSEE COALS.

489. Bituminous coal delivered to the United States penitentiary, Atlanta, Ga., Department of Justice, 1913–14. Price, $2.90 per ton.

490. Bituminous coal delivered to the United States penitentiary, Atlanta, Ga., Department of Justice, 1914–15. Contract guaranties: 1.5 per cent moisture, "as received"; 38 per cent volatile matter, 0.75 per cent sulphur, 7 per cent ash, 14,500 B. t. u., "dry coal." Price, $2.85 per ton.

491. Bituminous coal delivered to Fort Oglethorpe, Ga., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 2 per cent moisture, "as received"; 8 per cent ash, 14,000 B. t. u., "dry coal." Price, $3 per ton.

492. Bituminous coal delivered to the United States penitentiary, Atlanta, Ga., Department of Justice, 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 43.5 per cent volatile matter, 2.81 per cent sulphur, 5 per cent ash, 14,000 B. t. u., "dry coal." Price, $2.90 per ton.

493. Bituminous coal delivered to the United States penitentiary, Atlanta, Ga., Department of Justice, 1912–13. Contract guaranties: 2.5 per cent moisture, "as received"; 29 per cent volatile matter, 1 per cent sulphur, 8 per cent ash, 14,000 B. t. u., "dry coal." Price, $2.91 per ton.

TEXAS COALS.

494. Bituminous coal delivered to Fort Sam Houston, Tex., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 17 per cent ash, "dry coal"; 11,400 B. t. u., "as received." Price, $5.45 per ton.

495. Bituminous coal delivered to Fort McIntosh, Tex., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 16.53 per cent ash, "dry coal"; 11,588 B. t. u., "as received." Price, $5.60 per ton.

UTAH COALS.

496. Bituminous coal delivered to Fort Douglas, Utah, Quartermaster Corps, War Department, 1913–14. Contract guaranties: 4.7 per cent moisture, "as received"; 6.8 per cent ash, 13,480 B. t. u., "dry coal." Price, $5.26 per ton.

497. Bituminous coal delivered to Fort Douglas, Utah, Quartermaster Corps, War Department, 1912–13. Contract guaranties: 3 per cent moisture, "as received"; 5 per cent ash, 13,000 B. t. u., "dry coal." Price, $6.22 per ton.

498. Bituminous coal delivered to Fort Douglas, Utah, Quartermaster Corps, War Department, 1913–14. Contract guaranties: 4.7 per cent moisture, "as received"; 6.3 per cent ash, 13,610 B. t. u., "dry coal." Price, $5.26 per ton.

499. Bituminous coal delivered to the Presidio of Monterey, Cal., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 2.5 per cent moisture, "as received"; 3.5 per cent ash, and 13,810 B. t. u., "dry coal." Price, $2.44 per ton for delivery in July to September, 1914, inclusive; $2.72 per ton for delivery in October to December, 1914, inclusive, and $3.28 per ton for delivery in January to June, 1915, inclusive.

500. Bituminous coal delivered to Fort Douglas, Utah, Quartermaster Corps, War Department, 1911–12. Contract guaranties: 7 per cent ash, "dry coal"; 1[illegible]00 B. t. u., "as received." Price, $6.38 per ton.

VIRGINIA COALS.

501. Bituminous coal delivered to the Panama Railroad Co., at Lamberts Point, Va., in August, 1910.

502. Bituminous coal delivered to the United States engineer office, Charleston, S. C., War Department, 1912–13. Contract guaranties: 2.5 per cent moisture, 1 per cent sulphur, 6 per cent ash, 14,500 B. t. u., "as received." Price, $2.86 per ton.

503. Bituminous coal delivered to the Mountain Branch of the National Home for Disabled Volunteer Soldiers, National Soldiers' Home, Tenn., 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 36 per cent volatile matter, 0.75 per cent sulphur, 8 per cent ash, 13,500 B. t. u., "dry coal." Price, $1.80 per ton (2,000 pounds).

504. Bituminous coal delivered to the Mountain Branch of the National Home for Disabled Volunteer Soldiers, National Soldiers' Home, Tenn., 1911–12. Contract guaranties: 8 per cent ash, "dry coal"; 13,500 B. t. u., "as received." Price, $1.60 per ton (2,000 pounds).

505. Bituminous coal delivered to the Mountain Branch of the National Home for Disabled Volunteer Soldiers, National Soldiers' Home, Tenn., 1910–11. Contract guaranties same as No. 504. Price, $1.50 per ton (2,000 pounds).

506. Bituminous coal delivered to the United States engineer office, Georgetown, S. C., War Department, 1913–14. Contract guaranties: 2.5 per cent moisture, "as received"; 36 per cent volatile matter, 1 per cent sulphur, 6 per cent ash, 14,000 B. t. u., "dry coal." Price, $3.60 per ton (2,000 pounds).

507. Bituminous coal delivered to quartermaster vessels at Galveston, Tex., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 2 per cent moisture, "as received"; 38 per cent volatile matter, 0.75 per cent sulphur, 9 per cent ash, 14,000 B. t. u., "dry coal." Price, $5.90 per ton.

508. Bituminous coal delivered to the Mountain Branch of the National Home for Disabled Volunteer Soldiers, National Soldiers' Home, Tenn., 1914–15. Contract guaranties: 3 per cent moisture, "as received"; 34 per cent volatile matter, 0.75 per cent sulphur, 8 per cent ash, 13,500 B. t. u., "dry coal." Price, $1.80 per ton (2,000 pounds).

509. Bituminous coal delivered to the sixth lighthouse district, Charleston, S. C., Bureau of Lighthouses, Department of Commerce, 1914–15. Contract guaranties: 2 per cent moisture, "as received"; 35 per cent volatile matter, 0.75 per cent sulphur, 8 per cent ash, 14,000 B. t. u., "dry coal." Price, $4.05 per ton.

510. Bituminous coal delivered to the Mountain Branch of the National Home for Disabled Volunteer Soldiers, National Soldiers' Home, Tenn., 1912–13. Contract guaranties: 3 per cent moisture, "as received"; 8 per cent ash, 13,500 B. t. u., "dry coal." Price, $1.70 per ton (2,000 pounds).

511. Bituminous coal delivered to the United States engineer office, Charleston, S. C., War Department, 1913–14. Contract guaranties: 2.5 per cent moisture, "as received"; 36 per cent volatile matter, 1 per cent sulphur, 6 per cent ash, 14,000 B. t. u., "dry coal." Price, $3.30 per ton (2,000 pounds).

512. Semibituminous coal delivered to the navy yard at Norfolk, Va., Navy Department, 1909–10. Contract guaranties: 4 per cent ash, "dry coal"; 14,800 B. t. u., "as received." Price, $2.57 per ton.

513. Semibituminous coal delivered to the navy yard at Charleston, S. C., Navy Department, 1910–11. Contract guaranties: 5 per cent ash, "dry coal"; 15,000 B. t. u., "as received." Price, $3.60 per ton.

514. Semibituminous coal delivered to the navy yard at Norfolk, Va., Navy Department, 1910–11. Contract guaranties: 5 per cent ash, "dry coal"; 15,000 B. t. u., "as received." Price, $2.78 per ton.

WASHINGTON COALS.

515. Bituminous coal delivered to Fort McDowell, Cal., recruit depot, Quartermaster Corps, War Department, 1911–12. Contract guaranties: 7 per cent ash, "dry coal"; 12,790 B. t. u., "as received." Price, $6.15 per ton.

516. Bituminous coal delivered to Alcatraz, Cal., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 7 per cent ash, "dry coal"; 12,790 B. t. u., "as received." Price, $6.15 per ton.

517. Subbituminous coal delivered to Fort Worden, Wash., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 10.8 per cent ash, "dry coal"; 11,890 B. t. u., "as received." Price, $5.75 per ton.

518. Subbituminous coal delivered to Fort W. H. Seward, Alaska, Quartermaster Corps, War Department, 1911–12. Contract guaranties same as No. 517. Price, $8.20 per ton.

519. Subbituminous coal delivered to Fort Lawton, Wash., Quartermaster Corps, War Department, 1911–12. Contract guaranties same as No. 517. Price, $5 per ton.

520. Subbituminous coal delivered to Fort Casey, Wash., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 10.8 per cent ash, "dry coal"; 11,890 B. t. u., "as received." Price, $5.75 per ton.

521. Subbituminous coal delivered to Fort Casey, Wash., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 12 per cent moisture, "as received"; 14 per cent ash, 11,500 B. t. u., "dry coal." Price, $6.50 per ton.

522. Subbituminous coal delivered to Fort Lawton, Wash., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 12 per cent moisture, "as received"; 40 per cent volatile matter, 1 per cent sulphur, 14 per cent ash, 11,500 B. t. u., "dry coal." Price, $5.60 per ton.

523. Bituminous coal delivered to Vancouver Barracks, Wash., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 13 per cent ash, 12,900 B. t. u., "dry coal." Price, $3.65 per ton f. o. b. Roslyn, Wash.

524. Bituminous coal delivered to the post office, Spokane, Wash., Treasury Department, 1910–11. Price, $5.90 per ton.

525. Bituminous coal delivered to the United States engineer office, Portland, Oreg., War Department, 1912–13.

526. Bituminous coal delivered to the United States engineer office, Fort Stevens, Oreg., War Department, 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 34.2 per cent volatile matter, 0.3 per cent sulphur, 13 per cent ash, 12,900 B. t. u., "dry coal." Price, $2.75 per ton f. o. b. Beekman, Oreg.

527. Bituminous coal delivered to Fort George Wright, Wash., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 4 per cent moisture, "as received"; 12 per cent ash, 13,000 B. t. u., "dry coal." Price, $3.83 per ton.

528. Bituminous coal delivered to Vancouver Barracks, Wash., Quartermaster Corps, War Department, 1912–13. Contract guaranties and price same as No. 527.

529. Bituminous coal delivered to Fort Stevens, Oreg., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 4 per cent moisture, "as received"; 13 per cent ash, 12,600 B. t. u., "dry coal." Price, $4.08 per ton f. o. b. Ronald, Wash.

530. Bituminous coal delivered to Fort Stevens, Oreg., Quartermaster Corps, War Department, 1913–14. Contract guaranties same as No. 529. Price, $2.43 per ton f. o. b. Ronald, Wash.

531. Bituminous coal delivered to Vancouver Barracks, Wash., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 4 per cent moisture, "as received"; 12 per cent ash, 13,000 B. t. u., "dry coal." Price, $3.33 per ton.

532. Bituminous coal delivered to Fort Stevens, Oreg., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 4 per cent moisture, "as received"; 13 per cent ash, 12,800 B. t. u., "dry coal." Price, $3.25 per ton for delivery at Astoria, Oreg.

533. Bituminous coal delivered to the quartermaster depot, Seattle, Wash., Quartermaster Corps, War Department, 1914–15. Contract guaranties same as No. 532. Price, $12.95 per ton at Fort Liscum, $15.45 per ton at Cordova, $15.95 per ton at Seward, and $16.45 per ton at Valdez, Alaska.

534. Bituminous coal delivered to Fort Liscum, Alaska, Quartermaster Corps, War Department, 1913–14. Contract guaranties: 4 per cent moisture, "as received"; 12 per cent ash, 12,900 B. t. u., "dry coal." Price, $15.30 per ton.

535. Bituminous coal delivered to the United States engineer office, Fort Stevens, Oreg., War Department, 1914–15. Contract guaranties: 4 per cent moisture, "as received"; 37 per cent volatile matter, 0.3 per cent sulphur, 7 per cent ash, and 14,000 B. t. u., "dry coal." Price, $2.90 per ton.

536. Bituminous coal delivered to Fort Liscum, Alaska, Quartermaster Corps, War Department, 1911–12. Contract guaranties: 9.98 per cent ash, "dry coal"; 13,000 B. t. u., "as received." Price, $7.50 per ton delivered at Seattle, Wash.

537. Bituminous coal delivered to Fort Lawton, Wash., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 10 per cent ash, 13,000 B. t. u., "dry coal." Price, $9.25 per ton.

538. Bituminous coal delivered to Fort William H. Seward, Alaska, Quartermaster Corps, War Department, 1912–13. Contract guaranties: 4 per cent moisture, "as received"; 9.75 per cent ash, 13,000 B. t. u., "dry coal." Price, $9.50 per ton.

539. Bituminous coal delivered to Fort Stevens, Oreg., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 2.5 per cent moisture, "as received"; 11 per cent ash, 12,800 B. t. u., "dry coal." Price, $6.30 per ton.

540. Bituminous coal delivered to Fort Stevens, Oreg. (for vessels), Quartermaster Corps, War Department, 1913–14. Contract guaranties: 4 per cent moisture, "as received"; 11 per cent ash, 13,200 B. t. u., "dry coal." Price, $3.60 per ton f. o. b. Burnett, Wash.

541. Bituminous coal delivered to Fort Stevens, Oreg., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 9.98 per cent ash, "dry coal"; 12,500 B. t. u., "as received." Price, $6.15 per ton.

542. Bituminous coal delivered to Fort Liscum, Alaska, Quartermaster Corps, War Department, 1912–13. Contract guaranties: 4 per cent moisture, "as received"; 10.3 per cent ash, 12,600 B. t. u., "dry coal." Price, $13 per ton (sacked).

543. Bituminous coal delivered to Fort Liscum, Alaska, Quartermaster Corps, War Department, 1913–14. Contract guaranties: 6 per cent moisture, "as received"; 40.1 per cent volatile matter, 10 per cent ash, 12,800 B. t. u., "dry coal." Price, $13.25 per ton.

544. Bituminous coal delivered to Fort Flagler, Wash., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 6 per cent moisture, "as received"; 10 per cent ash, 12,800 B. t. u., "dry coal." Price $7 per ton ($3.50 per ton at the mine).

545. Bituminous coal delivered to the United States engineer office, Dalles or Celilo, Oreg., War Department, 1913–14. Contract guaranties: 4 per cent moisture, "as received"; 37 per cent volatile matter, 0.4 per cent sulphur, 11 per cent ash, 13,200 B. t. u., "dry coal." Price, $3.10 per ton f. o. b. Burnett, Wash.

546. Bituminous coal delivered to Fort Stevens, Oreg., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 8.5 per cent ash, "dry coal"; 13,000 B. t. u., "as received." Price, $6.40 per ton.

547. Bituminous coal delivered to the depot quartermaster, Seattle, Wash., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 10 per cent ash, "dry coal"; 12,300 B. t. u., "as received." Price, $5.50 per ton.

548. Bituminous coal delivered to Seattle or Tacoma, Wash., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 4 per cent moisture, "as received"; 10 per cent ash, 13,000 B. t. u., "dry coal." Price, $5.45 per ton at Seattle and $5.30 per ton at Tacoma.

549. Bituminous coal delivered to the depot quartermaster, Seattle, Wash., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 4.8 per cent moisture, "as received"; 12 per cent ash, 12,750 B. t. u., "dry coal." Price, $5.30 and $7.85 per ton, according to method of delivery.

550. Bituminous coal delivered to Fort Lawton, Wash., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 2.5 per cent moisture, "as received"; 10 per cent ash, 13,000 B. t. u., "dry coal." Price, $9.25 per ton.

551. Bituminous coal delivered to Fort Liscum, Alaska, Quartermaster Corps, War Department, 1912–13. Contract guaranties: 2.5 per cent moisture, "as received"; 10 per cent ash, 12,750 B. t. u., "dry coal." Price, $14.30 per ton (sacked).

552. Bituminous coal delivered to Fort Stevens, Oreg., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 5.6 per cent moisture, "as received"; 12 per cent ash, 13,600 B. t. u., "dry coal." Price, $7.98 per ton.

553. Bituminous coal delivered to Fort Stevens, Oreg. (steamers at Astoria, Oreg.), Quartermaster Corps, War Department, 1912–13. Contract guaranties same as No. 552. Price, $6.25 per ton.

554. Bituminous coal delivered to the Navy Department, Tacoma, Wash., in July, 1912. Samples collected when coal was loaded into cars at the mine.

555. Bituminous coal samples collected from the shipment represented by No. 554 when the coal was delivered at Tacoma, Wash.

WEST VIRGINIA COALS.

556. Bituminous coal delivered to the post office, Detroit, Mich., Treasury Department, 1912–13. Contract guaranties: 32 per cent volatile matter, 1 per cent sulphur, 7 per cent ash, "dry coal"; 14,200 B. t. u., "as received." Price, $3.02 per ton.

557. Semibituminous coal delivered to the main building of the Department of Agriculture, Washington, D. C., 1911–12. Contract guaranties: 6 per cent ash, "dry coal"; 14,600 B. t. u., "as received." Price, $3.20 per ton.

558. Semibituminous coal delivered to the Municipal Building, Washington, D. C., 1911–12. Contract guaranties: 4.9 per cent ash, "dry coal"; 14,600 B. t. u., "as received." Price, $3.10 per ton.

559. Semibituminous coal delivered to the State, War, and Navy Building, Washington, D. C., 1912–13. Contract guaranties: 2.5 per cent moisture, "as received"; 4.8 per cent ash, 14,900 B. t. u., "dry coal." Price, $3.39 per ton.

560. Semibituminous coal delivered to the shops at the propagating gardens, Washington, D. C., War Department, 1912–13. Contract guaranties same as No. 559. Price, $3.50 per ton.

561. Semibituminous coal delivered to the United States engineer office, Georgetown, S. C., War Department, 1912–13. Contract guaranties: 2.5 per cent moisture, 1 per cent sulphur, 6 per cent ash, 14,500 B. t. u., "as received." Price, $3.48 per ton.

562. Bituminous coal delivered to the United States courthouse and post office, Detroit, Mich., Treasury Department, 1909–10. Contract guaranties: 5 per cent ash, "dry coal"; 14,360 B. t. u., "as received." Price, $2.90 per ton.

563. Bituminous coal delivered to the customhouse, Detroit, Mich., Treasury Department, 1909–10. Contract guaranties and price same as No. 562.

564. Bituminous coal delivered to the Central Branch of the National Home for Disabled Volunteer Soldiers, National Military Home, Ohio, 1911–12. Contract guaranties: 5 per cent ash, "dry coal"; 14,410 B. t. u., "as received." Price, $2.55 per ton (2,000 pounds).

565. Bituminous coal delivered to the customhouse, Detroit, Mich., Treasury Department, 1910–11. Contract guaranties: 8 per cent ash, "dry coal"; 14,200 B. t. u., "as received." Price, $2.99 per ton.

566. Bituminous coal delivered to the United States courthouse and post office, Detroit, Mich., Treasury Department, 1910–11. Contract guaranties: 8 per cent ash, "dry coal"; 14,200 B. t. u., "as received." Price, $2.99 per ton.

567. Semibituminous coal delivered to the post office and subtreasury, Boston, Mass., Treasury Department, 1912–13. Contract guaranties: 22 per cent volatile matter, 1.5 per cent sulphur, 5 per cent ash, "dry coal"; 14,500 B. t. u., "as received." Price, $4.15 per ton.

568. Semibituminous coal delivered to the United States engineer office, Jacksonville, Fla., War Department, 1913–14. Contract guaranties: 1.7 per cent moisture, "as received"; 20.52 per cent volatile matter, 0.7 per cent sulphur, 6 per cent ash, 14,900 B. t. u., "dry coal." Price, $4.74 per ton.

569. Semibituminous coal delivered to Fort Banks, Mass., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 2 per cent moisture, "as received"; 7 per cent ash, 14,500 B. t. u., "dry coal." Price, $4.45 per ton.

570. Semibituminous coal delivered to Forts Crockett, Travis, and San Jacinto, Tex., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 0.8 per cent moisture, "as received"; 19.9 per cent volatile matter, 0.7 per cent sulphur, 9.7 per cent ash, 13,960 B. t. u., "dry coal." Price, $7.50 per ton.

571. Bituminous coal delivered to the United States engineer office, Georgetown, S. C., War Department, 1914–15. Contract guaranties: 1.72 per cent moisture, "as received"; 27.24 per cent volatile matter, 0.86 per cent sulphur, 4.03 per cent ash, 14,800 B. t. u., "dry coal." Price, $3.64 per ton (2,000 pounds).

572. Semibituminous coal delivered to the Northwestern Branch of the National Home for Disabled Volunteer Soldiers, National Home, Wis., 1910–11. Contract guaranties: 6 per cent ash, "dry coal"; 14,750 B. t. u., "as received." Price, $3.67 per ton (2,000 pounds).

573. Bituminous coal delivered to the Central Branch of the National Home for Disabled Volunteer Soldiers, National Military Home, Ohio, 1910–11. Contract guaranties: 6 per cent ash, "dry coal"; 14,300 B. t. u., "as received." Price, $2.50 per ton (2,000 pounds).

574. Semibituminous coal delivered to the third lighthouse district, Newport, R. I., Bureau of Lighthouses, Department of Commerce, 1914–15. Contract guaranties: 4 per cent moisture, "as received"; 22 per cent volatile matter, 2 per cent sulphur, 10 per cent ash, "dry coal"; 13,900 B. t. u., "as received." Price, $5.60 per ton.

575. Semibituminous coal delivered to the New National Museum, Washington, D. C., Smithsonian Institution, 1912–13. Contract guaranties: 8 per cent moisture, "as received"; 4 per cent ash, 14,850 B. t. u., "dry coal." Price, $3.10 per ton.

576. Semibituminous coal delivered to the main building of the Department of Agriculture, Washington, D. C., 1912–13. Contract guaranties: 2.5 per cent moisture, "as received"; 3.5 per cent ash, 14,900 B. t. u., "dry coal." Price, $3.19 per ton.

577. Semibituminous coal delivered to the Treasury Building, Washington, D. C., Treasury Department, 1912–13. Contract guaranties: 2.5 per cent moisture, "as received"; 3.5 per cent ash, 14,900 B. t. u., "dry coal." Price, $3.40 per ton.

578. Semibituminous coal delivered to the Winder Building, Washington, D. C., Treasury Department, 1912–13. Contract guaranties: 2.5 per cent moisture, "as received"; 3.5 per cent ash, 14,850 B. t. u., "dry coal." Price, $3.45 per ton.

579. Semibituminous coal delivered to the Government Printing Office, Washington, D. C., 1912–13. Contract guaranties: 2.5 per cent moisture, "as received"; 3.5 per cent ash, 14,900 B. t. u., "dry coal." Price, $3.35 per ton.

580. Semibituminous coal delivered to the Bureau of Engraving and Printing, Washington, D. C., Treasury Department, 1912–13. Contract guaranties same as No. 579. Price, $3.09 per ton.

581. Semibituminous coal delivered to the main building of the Department of Agriculture, Washington, D. C., 1913–14. Contract guaranties: 2.5 per cent moisture, "as received"; 22.64 per cent volatile matter, 1 per cent sulphur, 4.8 per cent ash, 14,900 B. t. u., "dry coal." Price, $3.42 per ton.

582. Semibituminous coal delivered to the Bureau of Engraving and Printing, Washington, D. C., Treasury Department, 1913–14. Contract guaranties same as No. 581. Price, $3.38 per ton.

583. Semibituminous coal delivered to the State, War, and Navy Building, Washington, D. C., 1913–14. Contract guaranties same as No. 581. Price, $3.59 per ton.

584. Semibituminous coal delivered to the Bureau of Engraving and Printing, Washington, D. C., Treasury Department, 1914–15. Contract guaranties same as No. 581. Price, $3.36 per ton.

585. Semibituminous coal delivered to the Department of Agriculture, Washington, D. C., 1914–15. Contract guaranties same as No. 581. Price, $3.41 per ton.

586. Semibituminous coal delivered to the State, War, and Navy Building, Washington, D. C., 1914–15. Contract guaranties same as No. 581. Price, $3.59 per ton.

587. Bituminous coal delivered to the United States courthouse and post office, Detroit, Mich., Treasury Department, 1907–8. Contract guaranties: 4.36 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3.30 per ton.

588. Bituminous coal delivered to the United States courthouse and post office, Detroit, Mich., Treasury Department, 1911–12. Contract guaranties: 7.63 per cent ash, "dry coal"; 14,200 B. t. u., "as received." Price, $2.97 per ton.

589. Bituminous coal delivered to the customhouse, Detroit, Mich., Treasury Department, 1911–12. Contract guaranties and price same as No. 588.

590. Bituminous coal delivered to the post office, Detroit, Mich., Treasury Department, 1913–14. Contract guaranties: 7.63 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3.15 per ton.

591. Bituminous coal delivered to the United States courthouse and post office, Detroit, Mich., Treasury Department, 1914–15. Contract guaranties: 32 per cent volatile matter, 1.5 per cent sulphur, 8 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3.05 per ton.

592. Bituminous coal delivered to Fort Crockett, Tex., Quartermaster Corps, War Department, 1912–13. Price, $7 per ton.

593. Bituminous coal delivered to the Marion Branch of the National Home for Disabled Volunteer Soldiers, National Military Home, Ind., 1913–14. Contract guaranties: 4 per cent moisture, "as received"; 34 per cent volatile matter, 0.85 per cent sulphur, 12 per cent ash; 12,700 B. t. u., "dry coal." Price, $2.60 per ton (2,000 pounds).

594. Bituminous coal delivered to the United States Indian school, Mount Pleasant, Mich., Office of Indian Affairs, Department of the Interior, 1914–15. Price, $3.297 per ton.

595. Bituminous coal delivered to the Marion Branch of the National Home for Disabled Volunteer Soldiers, National Military Home, Ind., 1914–15. Contract guaranties: 2.5 per cent moisture, "as received"; 34 per cent volatile matter, 1 per cent sulphur, 9 per cent ash; and 13,500 B. t. u., "dry coal." Price, $2.50 per ton (2,000 pounds).

596. Bituminous coal delivered to the United States engineer office, Grand Rapids, Mich., War Department, 1914–15. Contract guaranties: 2 per cent moisture, "as received"; 35 per cent volatile matter, 0.8 per cent sulphur, 5.91 per cent ash, 14,300 B. t. u., "dry coal." Price per ton (2,000 pounds), $3.05 for delivery at St. Joseph, South Haven, Holland, Grand Haven, and Muskegon, Mich.; $3.25 at Ludington, Manistee, and Frankfort, Mich.; and $3.40 at Charlevoix, Mich.

597. Bituminous coal delivered to the United States courthouse and post office, Grand Rapids, Mich., Treasury Department, 1911–12. Contract guaranties: 5.05 per cent ash, "dry coal"; 14,500 B. t. u., "as received." Price, $3.58 per ton.

598. Bituminous coal delivered to the Central Branch of the National Home for Disabled Volunteer Soldiers, National Military Home, Ohio, 1913–14. Contract guaranties: 2.5 per cent moisture, "as received"; 33 per cent volatile matter, 1.25 per cent sulphur, 8 per cent ash, 14,200 B. t. u., "dry coal." Price, $2.68 per ton (2,000 pounds).

599. Bituminous coal delivered to the Wagner Wells Pumping Station of the Central Branch of the National Home for Disabled Volunteer Soldiers, National Military Home, Ohio, 1913–14. Contract guaranties same as No. 598. Price, $2.33 per ton (2,000 pounds).

600. Bituminous coal delivered to the Central Branch of the National Home for Disabled Volunteer Soldiers, National Military Home, Ohio, 1914–15. Contract guaranties: 2 per cent moisture, "as received"; 33 per cent volatile matter, 1.25 per cent sulphur, 7.5 per cent ash, 14,200 B. t. u., "dry coal." Price, $2.60 per ton (2,000 pounds).

601. Bituminous coal delivered to the United States courthouse and post office, Detroit, Mich., Treasury Department, 1908–9. Contract guaranties: 6.1 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $3 per ton.

602. Bituminous coal delivered to the customhouse, Detroit, Mich., Treasury Department, 1908–9. Contract guaranties and price same as No. 601.

603. Bituminous coal delivered to the Central Branch of the National Home for Disabled Volunteer Soldiers, National Military Home, Ohio, 1912–13. Contract guaranties: 1.2 per cent moisture, "as received"; 6 per cent ash, 14,210 B. t. u., "dry coal." Price, $2.50 per ton (2,000 pounds).

604. Bituminous coal delivered to the Wagner Wells Pumping Station of the Central Branch of the National Home for Disabled Volunteer Soldiers, National Military Home, Ohio, 1912–13. Contract guaranties same as No. 603. Price, $2.15 per ton (2,000 pounds).

605. Bituminous coal delivered to the Marion Branch of the National Home for Disabled Volunteer Soldiers, National Military Home, Ind., 1911–12. Contract guaranties: 8 per cent ash, "dry coal"; 13,600 B. t. u., "as received." Price, $2.20 per ton (2,000 pounds).

606. Bituminous coal delivered to the Marion Branch of the National Home for Disabled Volunteer Soldiers, National Military Home, Ind., 1912–13. Contract guaranties: 1.25 per cent moisture, "as received"; 10 per cent ash, 13,700 B. t. u., "dry coal." Price, $2.25 per ton (2,000 pounds).

607. Semibituminous coal delivered to Fort Dade, Fla., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 6 per cent ash, "dry coal"; 14,600 B. t. u., "as received." Price, $5.65 per ton.

608. Semibituminous coal delivered to Fort Dade, Fla., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 5 per cent moisture, "as received"; 0.75 per cent sulphur, 7.5 per cent ash, 14,250 B. t. u., "dry coal." Price, $8.25 per ton.

609. Semibituminous coal delivered to Fort Dade, Fla. (vessels at Tampa, Fla.), Quartermaster Corps, War Department, 1913–14. Contract guaranties same as No. 608. Price, $5.50 per ton.

610. Semibituminous coal delivered to the United States engineer office, Tampa, Fla., for use on vessels, War Department, 1914–15. Contract guaranties: 4.5 per cent moisture, "as received"; 20 per cent volatile matter, 1 per cent sulphur, 7.5 per cent ash, 14,500 B. t. u., "dry coal." Price, $5.50 per ton.

611. Semibituminous coal delivered to the United States engineer office, Norfolk, Va., War Department, 1914–15. Contract guaranties: 1.5 per cent moisture, "as received"; 18 per cent volatile matter, 0.65 per cent sulphur, 5 per cent ash, 14,800 B. t. u., "dry coal." Price, $2.53 per ton (2,000 pounds).

612. Semibituminous coal delivered to the fifth lighthouse district, Norfolk, Va., Bureau of Lighthouses, Department of Commerce, 1914–15. Contract guaranties: 2 per cent moisture, "as received"; 19 per cent volatile matter, 1 per cent sulphur, 6 per cent ash, 14,850 B. t. u., "dry coal." Price, $2.83 per ton.

613. Semibituminous coal delivered to Fort Dade, Fla., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 5 per cent moisture, "as received"; 20 per cent volatile matter, 0.75 per cent sulphur, 7.5 per cent ash, 14,250 B. t. u., "dry coal." Price $5.50 per ton on boats at Tampa, Fla., and $8 per ton in bins at the fort.

614. Semibituminous coal delivered to Fort Screven, Ga., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 2 per cent moisture, "as received"; 6.5 per cent ash, 14,700 B. t. u., "dry coal." Price, $4.82 per ton in vessels at Savannah, Ga., and $5.76 per ton at the fort.

615. Semibituminous coal delivered to Fort McKinley, Me., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 6 per cent ash, "dry coal"; 14,300 B. t. u., "as received." Price, $6.67 per ton.

616. Semibituminous coal delivered to the naval hospital, Norfolk, Va., Navy Department, 1909-10. Contract guaranties; 6 per cent ash, 0.75 per cent sulphur, "dry coal"; 14,600 B. t. u., "as received." Price, $2.85 per ton.

617. Semibituminous coal delivered to the Northwestern Branch of the National Home for Disabled Volunteer Soldiers, National Home, Wis., 1911–12. Contract guaranties: 7 per cent ash, "dry coal"; 14,089 B. t. u., "as received." Price, $3.45 per ton (2,000 pounds).

618. Semibituminous coal delivered to the naval hospital, Norfolk, Va., Navy Department, 1911–12. Contract guaranties: 6 per cent ash, 14,600 B. t. u., "as received." Price, $2.95 per ton.

619. Semibituminous coal delivered to the United States engineer office, Charleston, S. C., War Department, 1912–13. Contract guaranties: 2.5 per cent moisture, 1 per cent sulphur, 6 per cent ash, 14,500 B. t. u., "as received." Price, $3.65 per ton (2,000 pounds).

620. Semibituminous coal delivered to the naval hospital, Norfolk, Va., Navy Department, 1912–13. Contract guaranties: 1.57 per cent moisture, "as received"; 18.3 per cent volatile matter, 0.7 per cent sulphur, 5.5 per cent ash, 14,850 B. t. u., "dry coal." Price, $2.89 per ton.

621. Semibituminous coal delivered to Fort Adams, R. I., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 9 per cent ash, "dry coal"; 14,000 B. t. u., "as received." Price, $5.25 per ton.

622. Semibituminous coal delivered to Fort Adams, R. I., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 4 per cent moisture, "as received"; 10 per cent ash, 13,850 B. t. u., "dry coal." Price, $5.25 per ton.

623. Semibituminous coal delivered to Fort Greble, R. I., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 4 per cent moisture, "as received"; 9 per cent ash, 13,800 B. t. u., "dry coal." Price, $5.20 per ton.

624. Semibituminous coal delivered to the navy yard at Norfolk, Va., Navy Department, 1911–12. Contract guaranties: 7 per cent ash, 14,700 B. t. u., "as received." Price, $2.50 per ton.

625. Semibituminous coal delivered to harbor boats, depot quartermaster, Boston, Mass., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 1 per cent moisture, "as received"; 6.5 per cent ash, 14,600 B. t. u., "dry coal." Price, $4.09 per ton.

626. Semibituminous coal delivered to Fort Warren, Mass., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 1.5 per cent moisture, "as received"; 6.5 per cent ash, 14,500 B. t. u., "dry coal." Price, $5.12 per ton.

627. Semibituminous coal delivered to the quartermaster depot, Boston, Mass., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 1.5 per cent moisture, "as received"; 17.5 per cent volatile matter, 0.75 per cent sulphur, 6.5 per cent ash, 14,500 B. t. u., "dry coal." Price, $3.98 per ton.

628. Semibituminous coal delivered to Fort Andrews, Mass., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 1.5 per cent moisture, "as received"; 6.5 per cent ash, 14,500 B. t. u., "dry coal." Price, $5.27 per ton.

629. Bituminous coal delivered to the District of Columbia workhouse, Occoquan, Va., 1912–13. Contract guaranties: 3.5 per cent moisture, "as received"; 7.5 per cent ash, 14,000 B. t. u., "dry coal." Price, $3.19 per ton.

630. Bituminous coal delivered to the District of Columbia workhouse, Occoquan, Va., 1914–15. Contract guaranties: 3.5 per cent moisture, "as received"; 36 per cent volatile matter, 1.5 per cent sulphur, 7.5 per cent ash, 14,000 B. t. u., "dry coal." Price, $3.52 per ton.

631. Semibituminous coal delivered to the naval hospital, Norfolk, Va., Navy Department, 1910–11. Contract guaranties: 6 per cent ash, "dry coal"; 14,500 B. t. u., "as received." Price, $2.93 per ton.

632. Semibituminous coal delivered to Fort Screven, Ga., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 6 per cent ash, "dry coal"; 14,850 B. t. u., "as received." Price, $5.28 per ton.

633. Semibituminous coal delivered to the League Island Navy Yard, Philadelphia, Pa., Navy Department, 1908–9. Contract guaranties: 7 per cent ash, "dry coal"; 14,250 B. t. u., "as received." Price, $2.92 per ton.

634. Semibituminous coal delivered to Picatinny Arsenal, Dover, N. J., War Department, 1910–11. Contract guaranties: 8 per cent ash, "dry coal"; 14,100 B. t. u., "as received." Price, $3.42 per ton.

635. Semibituminous coal delivered to the Government Hospital for the Insane, Washington, D. C., Department of the Interior, 1912–13. Contract guaranties: 1.25 per cent moistrue, "as received"; 8 per cent ash, 14,000 B. t. u., "dry coal." Price, $2.65 per ton.

636. Semibituminous coal delivered to the Picatinny Arsenal, Dover, N. J., War Department, 1911–12. Contract guaranties: 8.5 per cent ash, "dry coal"; 14,145 B. t. u., "as received." Price, $3.25 per ton.

637. Bituminous coal delivered to the Marion Branch of the National Home for Disabled Volunteer Soldiers, National Military Home, Ind., 1910–11. Contract guaranties: 9 per cent ash, "dry coal"; 12,500 B. t. u., "as received." Price, $2.25 per ton (2,000 pounds).

638. Semibituminous coal delivered to the post office and subtreasury, Boston, Mass., Treasury Department, 1911–12. Contract guaranties: 5.25 per cent ash, "dry coal"; 14,500 B. t. u., "as received." Price, $4.05 per ton.

639. Semibituminous coal delivered to Watertown Arsenal, Mass., War Department, 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 18 per cent volatile matter, 0.65 per cent sulphur, 5.5 per cent ash, 14,850 B. t. u., "dry coal." Price, $4.60 per ton.

640. Semibituminous coal delivered to Watertown Arsenal, Watertown, Mass., War Department, 1914–15. Contract guaranties: 3 per cent moisture, "as received"; 18 per cent volatile matter, 0.7 per cent sulphur, 5.5 per cent ash, 14,850 B. t. u., "dry coal." Price, $4.35 per ton.

641. Semibituminous coal delivered to the Southern Branch of the National Home for Disabled Volunteer Soldiers, National Soldiers' Home, Va., 1911–12. Contract guaranties: 4 per cent ash, "dry coal"; and 14,750 B. t. u., "as received." Price, $2.77 per ton.

642. Semibituminous coal delivered to the Watertown Arsenal, Watertown, Mass., War Department, 1911–12. Contract guaranties: 5.9 per cent ash, "dry coal"; 14,500 B. t. u., "as received." Price, $4.08 per ton.

643. Semibituminous coal delivered to the Southern Branch of the National Home for Disabled Volunteer Soldiers, National Soldiers' Home, Va., 1914–15. Contract guaranties: 2.75 per cent moisture, "as received"; 18 per cent volatile matter, 0.6 per cent sulphur, 5.5 per cent ash, 14,800 B. t. u., "dry coal." Price, $2.94 per ton.

644. Semibituminous coal delivered to the navy yard at Norfolk, Va., Navy Department, 1912–13. Contract guaranties: 2.5 per cent moisture, "as received"; 17 per cent volatile matter, 0.6 per cent sulphur, 5 per cent ash, 15,000 B. t. u., "dry coal." Price, $2.63 per ton.

645. Semibituminous coal delivered to the navy yard at Washington, D. C., Navy Department, 1912–13. Contract guaranties: 2 per cent moisture, "as received"; 19 per cent volatile matter, 1 per cent sulphur, 3 per cent ash, 15,100 B. t. u., "dry coal." Price, $2.95 per ton.

646. Semibituminous coal delivered to the navy yard at Washington, D. C., Navy Department, 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 22 per cent volatile matter, 1 per cent sulphur, 4 per cent ash, 15,000 B. t. u., "dry coal." Price, $3.10 per ton.

647. Semibituminous coal delivered to the navy yard at Charleston, S. C., Navy Department, 1908–9. Contract guaranties: 7 per cent ash, "dry coal"; 14,500 B. t. u., "as received." Price, $4.03 per ton.

648. Semibituminous coal delivered to the Bureau of Engraving and Printing, Washington, D. C., Treasury Department, 1911–12. Contract guaranties: 5 per cent ash, "dry coal"; 14,700 B. t. u., "as received." Price, $3.15 per ton.

649. Semibituminous coal delivered to the State, War, and Navy Building, Washington, D. C., 1911–12. Contract guaranties: 5 per cent ash, "dry coal"; 14,700 B. t. u., "as received." Price, $3.45 per ton.

650. Semibituminous coal delivered to the Treasury Building, Washington, D. C., Treasury Department, 1911–12. Contract guaranties: 5 per cent ash, "dry coal"; 14,700 B. t. u., "as received." Price, $3.60 per ton.

651. Semibituminous coal delivered to the Naval Medical School Hospital, Washington, D. C., Navy Department, 1911–12. Contract guaranties: 5 per cent ash, 14,300 B. t. u., "as received." Price, $3.35 per ton.

652. Semibituminous coal delivered to the Weather Bureau, Bluemont, Va., Department of Agriculture, 1912–13. Contract guaranties: 2 per cent moisture, "as received"; 5 per cent ash, 14,600 B. t. u., "dry coal." Price, $3.80 per ton.

653. Semibituminous coal delivered to the second lighthouse district, Boston, Mass., Bureau of Lighthouses, Department of Commerce, 1914–15. Contract guaranties: 2.5 per cent moisture, "as received"; 18 per cent volatile matter, 1 per cent sulphur, 6 per cent ash, 14,750 B. t. u., "dry coal." Price, $4.12 per ton.

654. Bituminous coal delivered to Galveston, Tex. (for vessels), Quartermaster Corps, War Department, in June and July, 1914.

655. Semibituminous coal delivered to Freedmen's Hospital, Washington, D. C., Department of the Interior, 1911–12. Contract guaranties: 5 per cent ash, "dry coal"; 14,500 B. t. u., "as received." Price, $3.44 per ton.

656. Semibituminous coal delivered to the fourth lighthouse district, Philadelphia, Pa., Bureau of Lighthouses, Department of Commerce, 1911–12. Price, $2.65 per ton.

657. Semibituminous coal delivered to the Panama Railroad Co. (bunker coal), at New York, N. Y., 1910–11. Contract guaranty: 14,000 B. t. u., "as received." Price, $2.77 per ton.

658. Semibituminous coal delivered to the Government Hospital for the Insane, Washington, D. C., Department of the Interior, 1911–12. Contract guaranties: 6 per cent ash, "dry coal"; 14,200 B. t u., "as received." Price, $2.75 per ton.

659. Semibituminous coal delivered to Fort Howard, Md., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 7 per cent ash, 14,100 B. t. u., "dry coal." Price, $2.85 per ton.

660. Semibituminous coal delivered to Fort Howard, Md., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 6 per cent ash, "dry coal"; 14,200 B. t. u., "as received." Price, $2.70 per ton delivered to vessels.

661. Semibituminous coal delivered to Fort Howard, Md., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 3 per cent moisture, "as received"; 6 per cent ash, 14,400 B. t. u., "dry coal." Price, $2.70 per ton for delivery to vessels and $3.38 per ton for delivery to post.

662. Semibituminous coal delivered to the Southern Branch of the National Home for Disabled Volunteer Soldiers, National Soldiers' Home, Va., 1910–11. Contract guaranties: 4 per cent ash, "dry coal"; 14,750 B. t. u., "as received." Price, $2.89 per ton.

663. Semibituminous coal delivered to Winder Building, Washington, D. C., Treasury Department, 1910–11. Contract guaranties: 5 per cent ash, "dry coal"; 14,700 B. t. u., "as received." Price, $3.35 per ton.

664. Semibituminous coal delivered to the Bureau of Engraving and Printing, Washington, D. C., Treasury Department, 1910–11. Contract guaranties:

4 per cent ash, "dry coal"; 14,710 B. t. u., "as received." Price, $3.19 per ton.

665. Semibituminous coal delivered to the Treasury Building, Washington. D. C., Treasury Department, 1910–11. Contract guaranties: 5 per cent ash, "dry coal"; 14,700 B. t. u., "as received." Price, $3.30 per ton.

666. Semibituminous coal delivered to Fort Williams, Me., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 6 per cent ash, "dry coal"; 14,300 B. t. u., "as received." Price, $4.65 per ton, delivery at Portland, Me.

667. Semibituminous coal delivered to Fort Monroe, Va., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 6 per cent ash "dry coal"; 14,600 B. t. u., "as received." Price, $3.11 per ton for delivery to post and $3.29 per ton for delivery at artillery school.

668. Semibituminous coal delivered to the Winder Building, Washington, D. C., Treasury Department, 1911–12. Contract guaranties: 5 per cent ash, "dry coal"; 14,600 B. t. u., "as received." Price $3.50 per ton.

669. Semibituminous coal delivered to Fort Monroe, Va., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 2.5 per cent moisture, "as received"; 6 per cent ash, 14,850 B. t. u., "dry coal." Price, $3.09 per ton for delivery at the artillery school.

670. Semibituminous coal delivered to Fort Williams, Me., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 4.5 per cent moisture, "as received"; 6 per cent ash, 14,500 B. t. u., "dry coal." Price, $4.80 per ton, delivery at Portland, Me.

671. Semibituminous coal delivered to the Southern Branch of the National Home for Disabled Volunteer Soldiers, National Soldiers' Home, Va., 1912–13. Contract guaranties: 2 per cent moisture, "as received"; 4 per cent ash, 14,950 B. t. u., "dry coal." Price, $2.76 per ton.

672. Semibituminous coal delivered to Fort Williams, Me., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 3.5 per cent moisture, "as received"; 22 per cent volatile matter, 1 per cent sulphur, 6 per cent ash, 14,300 B. t. u., "dry coal." Price, $5.30 per ton for delivery at post and $4.90 per ton for delivery to vessels.

673. Semibituminous coal delivered to the Southern Branch of the National Home for Disabled Volunteer Soldiers, National Soldiers' Home, Va., 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 22 per cent volatile matter, 0.95 per cent sulphur, 6.5 per cent ash, 14,800 B. t. u., "dry coal." Price, $3.13 per ton.

674. Semibituminous coal delivered to the United States engineer office, Georgetown, S. C., War Department, 1912–13. Contract guaranties: 2.5 per cent moisture, 1 per cent sulphur, 6 per cent ash, 14,500 B. t. u., "as received." Price, $3.65 per ton (2,000 pounds).

675. Semibituminous coal delivered to the District Building, Washington, D. C., 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 22 per cent volatile matter, 1 per cent sulphur, 5 per cent ash, 15,000 B. t. u., "dry coal." Price, $3.65 per ton.

676. Semibituminous coal delivered to the Treasury Building, Washington, D. C., Treasury Department, 1913–14. Contract guaranties: 3.5 per cent moisture, "as received"; 5 per cent ash, 15,000 B. t. u., "dry coal." Price, $3.95 per ton.

677. Semibituminous coal delivered to the New National Museum, Washington, D. C., Smithsonian Institution, 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 5 per cent ash, 15,000 B. t. u., "dry coal." Price, $3.90 per ton.

678. Semibituminous coal delivered to the Government Printing Office, Washington, D. C., 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 22 per cent volatile matter, 1 per cent sulphur, 5 per cent ash, 15,000 B. t. u., "dry coal." Price, $3.75 per ton.

679. Semibituminous coal delivered to the Treasury Building, Washington, D. C., Treasury Department, 1914–15. Contract guaranties: 3 per cent moisture, "as received"; 22 per cent volatile matter, 1 per cent sulphur, 5 per cent ash, 14,895 B. t. u., "dry coal." Price, $3.73 per ton.

680. Semibituminous coal delivered to the District Building, Washington, D. C., 1914–15. Contract guaranties: 2.5 per cent moisture, "as received"; 22 per cent volatile matter, 1 per cent sulphur, 5 per cent ash, 14,895 B. t. u., "dry coal." Price, $3.64 per ton.

681. Semibituminous coal delivered to Fort Monroe, Va., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 2.5 per cent moisture, "as received"; 6 per cent ash, 14,850 B. t. u., "dry coal." Price, $3.505 per ton for delivery at fort, and $3.22 per ton f. o. b. vessels at Norfolk, Va.

682. Semibituminous coal delivered to the navy yard at Washington, D. C., Navy Department, 1914–15. Contract guaranties: 3 per cent moisture, "as received"; 22 per cent volatile matter, 1 per cent sulphur, 4 per cent ash, 14,900 B. t. u., "dry coal." Price, $3.05 per ton.

683. Semibituminous coal delivered to the Panama Railroad Co., Newport News, Va., 1908–9. Contract guaranty: 14,600 B. t. u., "as received." Price, $2.65 to $2.80 per ton, f. o. b. steamers; April 1 to August 31, 1908, $2.65; September 1, 1908, to March 31, 1909, $2.80.

684 and **685.** Semibituminous coal delivered to the Panama Railroad Co., at Sewalls Point, Norfolk, Va., 1910–11. Contract guaranty: 14,600 B. t. u., "as received." Price, $2.60 per ton.

686. Semibituminous coal delivered to the Panama Railroad Co., Newport News, Va., 1911–12. Contract guaranty: 14,600 B. t. u., "as received." Price, $2.51 per ton.

687. Semibituminous coal delivered to the Panama Railroad Co., Newport News, Va., 1912–13. Contract guaranty: 14,800 B. t. u., "dry coal." Price, $2.70 per ton.

688. Semibituminous coal delivered to the Panama Railroad Co., at Sewalls Point, Norfolk, Va., 1912–13. Contract guaranty: 14,800 B. t. u., "dry coal." Price, $2.70 per ton.

689. Semibituminous coal delivered to the Panama Railroad Co., at Sewalls Point, Norfolk, Va., 1913–14. Contract guaranty and price same as No. 688.

WEST VIRGINIA AND VIRGINIA COALS.

690. Semibituminous coal delivered to the United States engineer office, Charleston, S. C., War Department, 1910–11. Contract guaranty: 6 per cent ash, "dry coal"; 14,500 B. t. u., "as received." Price, $3.23 per ton.

691. Semibituminous coal delivered to Fort Monroe, Va., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 6 per cent ash, "dry coal"; 14,600 B. t. u., "as received." Price, $2.95 per ton.

692. Semibituminous coal delivered to Fort Monroe, Va., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 2.67 per cent moisture, "as received"; 6 per cent ash, 14,900 B. t. u., "dry coal." Price, $2.95 per ton.

693. Semibituminous coal delivered to the navy yard at Norfolk, Va., Navy Department, 1913–14. Contract guaranties: 2.54 per cent moisture, "as received"; 19.35 per cent volatile matter, 0.7 per cent sulphur, 6.5 per cent ash, 14,950 B. t. u., "dry coal." Price, $2.85 per ton.

694. Semibituminous coal delivered to the naval hospital, Norfolk, Va., Navy Department, 1913–14. Contract guaranties same as No. 693. Price, $3.21 per ton.

695. Semibituminous coal delivered to Fort Monroe, Va. (vessels at Norfolk and Lamberts Point, Va.), Quartermaster Corps, War Department, 1913–14. Contract guaranties: 2.67 per cent moisture, "as received"; 22 per cent volatile matter, 2 per cent sulphur, 6 per cent ash, 14,900 B. t. u., "dry coal." Price, $2.95 per ton.

696. Semibituminous coal delivered to New Bedford, Mass., second lighthouse district, Bureau of Lighthouses, Department of Commerce, 1913–14. Contract guaranties: 3 per cent moisture, "as received"; 19 per cent volatile matter, 0.75 per cent sulphur, 6 per cent ash, 14,900 B. t. u., "dry coal." Price, $4.23 per ton.

697. Semibituminous coal delivered to the navy yard at Norfolk, Va., Navy Department, 1914–15. Contract guaranties: 2.75 per cent moisture, "as received"; 18 to 20 per cent volatile matter, 0.05 to 1 per cent sulphur, 5 per cent ash, 14,800 B. t. u., "dry coal." Price, $2.80 per ton.

698. Semibituminous coal delivered to the naval hospital, Norfolk, Va., Navy Department, 1914–15. Contract guaranties same as No. 697. Price, $3.16 per ton.

699. Semibituminous coal delivered to the Northwestern Branch of the National Home for Disabled Volunteer Soldiers, National Home, Wis., 1914–15. Contract guaranties: 4 per cent moisture, "as received"; 19 per cent volatile matter, 0.75 per cent sulphur, 5 per cent ash, 14,750 B. t. u., "dry coal." Price, $3.07 per ton (2,000 pounds).

700. Semibituminous coal delivered to the second lighthouse district, New Bedford, Mass., Bureau of Lighthouses, Department of Commerce, 1914–15. Contract guaranties: 3 per cent moisture, "as received"; 20 per cent volatile matter, 0.6 per cent sulphur, 6 per cent ash, 14,750 B. t. u., "dry coal." Price, $4.28 per ton.

701. Semibituminous coal delivered to Fort Monroe, Va., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 3.5 per cent moisture, "as received"; 6.5 per cent ash, 14,850 B. t. u., "dry coal." Price, $2.95 per ton at Norfolk, Va.

702. Semibituminous coal delivered to the navy yard at Charleston, S. C., Navy Department, 1914–15. Contract guaranties: 2 per cent moisture, "as received"; 19.35 per cent volatile matter, 0.6 per cent sulphur, 6 per cent ash, 14,800 B. t. u., "dry coal." Price, $3.92 per ton.

703. Semibituminous coal delivered to the Panama Railroad Co. at Norfolk, Va., 1908–9. Contract guaranty: 14,600 B. t. u., "as received." Price, per ton, f. o. b. steamers, April 1 to August 31, 1908, $2.65; September 1, 1908, to March 31, 1909, $2.80.

704. Semibituminous coal delivered to the Panama Railroad Co. at Norfolk, Va., in 1909–10. Contract guaranty: 14,600 B. t. u., "as received." Price, per ton, f. o. b. steamers, April 1 to August 31, 1909, $2.34; September 1, 1909, to March 31, 1910, $2.44.

705, 706, 707. Semibituminous coal delivered to the Panama Railroad Co. at Lamberts Point, Va., 1910–11. Contract guaranty: 14,600 B. t. u., "as received." Price, $2.60 per ton.

708. Semibituminous coal delivered to the Panama Railroad Co. at Lamberts Point, Va., 1911–12. Contract guaranty: 14,600 B. t. u., "as received." Price, $2.51 per ton.

709, 710, 711. Semibituminous coal delivered to the Panama Railroad Co. at Lamberts Point, Va. Contract guaranty: 14,800 B. t. u., "dry coal." Price, $2.70 per ton. No. 709 was delivered in 1912–13, No. 710 in 1913–14, and No. 711 in 1914–15.

712. Semibituminous coal delivered to the Panama Railroad Co. at Lamberts Point, Va., 1914–15. Contract guaranties: 3 per cent moisture, "as received"; 21 per cent volatile matter, 1.25 per cent sulphur, 7 per cent ash, 14,700 B. t. u., "dry coal." Price, $2.70 per ton.

WYOMING COALS.

713. Subbituminous coal delivered to Fort Yellowstone, Wyo., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 9 per cent moisture, "as received"; 3 per cent ash, 12,000 B. t. u., "dry coal." Price, $2.30 per ton f. o. b. Kirby, Wyo.

714. Bituminous coal delivered to Boise Barracks, Idaho, Quartermaster Corps, War Department, 1911–12. Contract guaranties: 10 per cent ash, "dry coal"; 12,500 B. t. u., "as received." Price, $8.40 per ton before September 1, 1911, and $8.96 per ton after September 1, 1911.

715. Subbituminous coal delivered to the Battle Mountain Sanitarium of the National Home for Disabled Volunteer Soldiers, Hot Springs, S. Dak., 1912–13. Contract guaranties: 20 per cent moisture, "as received"; 6 per cent ash, 12,500 B. t. u., "dry coal." Price, $3.30 per ton (2,000 pounds).

716. Subbituminous coal delivered to the Rapid City Indian School, Rapid City, S. Dak., Office of Indian Affairs, Department of the Interior, 1910–11. Contract guaranties: 3 per cent ash, "dry coal"; 10,500 B. t. u., "as received." Price, $4.70 per ton (2,000 pounds).

717. Subbituminous coal delivered to the Blackfeet Indian Agency, Browning, Mont., Office of Indian Affairs, Department of the Interior, 1910–11. Contract guaranties: 3 per cent ash, "dry coal"; 10,500 B. t. u., "as received." Price, $6 per ton (2,000 pounds).

718. Subbituminous coal delivered to the Indian school, Crow Agency Station, Mont., Office of Indian Affairs, Department of the Interior, 1910–11. Contract guaranties same as No. 717. Price $2,60 per ton (2,000 pounds).

719. Subbituminous coal delivered to Fort Keogh, Mont., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 20 per cent moisture, "as received"; 46 per cent volatile matter, 1 per cent sulphur, 4 per cent ash, 12,000 B. t. u., "dry coal." Price, $3.98 per ton.

720. Subbituminous coal delivered to Fort Meade, S. Dak., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 22 per cent moisture, "as received"; 40 per cent volatile matter, 1 per cent sulphur, 3 per cent ash, 12,500 B. t. u., "dry coal." Price, $5.20 per ton.

721. Subbituminous coal delivered to Fort Robinson, Nebr., Quartermaster Corps, War Department, 1914–15. Contract guaranties same as No. 720. Price, $4.80 per ton.

722. Subbituminous coal delivered to Fort Robinson, Nebr., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 3.5 per cent ash, "dry coal"; 9,700 B. t. u., "as received." Price, $4.45 per ton.

723. Subbituminous coal delivered to Fort Mackenzie, Wyo., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 3.5 per cent ash, "dry coal"; 9,700 B. t. u., "as received." Price, $2.15 per ton.

724. Subbituminous coal delivered to Fort Mackenzie, Wyo., Quartermaster Corps, War Department, 1912–13. Contract guaranties: 15 per cent moisture, "as received"; 4 per cent ash, 10,000 B. t. u., "dry coal." Price, $2 per ton.

725. Subbituminous coal delivered to Fort Meade, S. Dak., Quartermaster Corps, War Department, 1911–12. Contract guaranties: 6 per cent ash, "dry coal"; 9,500 B. t. u., "as received." Price, $6.50 per ton.

726. Subbituminous coal delivered to Fort Robinson, Nebr., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 15 per cent moisture, "as received"; 40 per cent volatile matter, 1 per cent sulphur, 3 per cent ash, 12,500 B. t. u., "dry coal." Price, $4.93 per ton.

727. Subbituminous coal delivered to the Battle Mountain Sanitarium of the National Home for Disabled Volunteer Soldiers, Hot Springs, S. Dak., 1913–14. Contract guaranties: 18 per cent moisture, "as received"; 44 per cent volatile matter, 0.43 per cent sulphur, 3 per cent ash, 12,585 B. t. u., "dry coal." Price, $3.30 per ton (2,000 pounds).

728. Subbituminous coal delivered to Fort Meade, S. Dak., Quartermaster Corps, War Department, 1913–14.

729. Subbituminous coal delivered to the Battle Mountain Sanitarium of the National Home for Disabled Volunteer Soldiers, Hot Springs, S. Dak., 1910–11. Contract guaranties: 5 per cent ash, "dry coal"; 10,500 B. t. u., "as received." Price, $3.30 per ton (2,000 pounds).

730. Subbituminous coal delivered to the Battle Mountain Sanitarium of the National Home for Disabled Volunteer Soldiers, Hot Springs, S. Dak., 1914–15. Contract guaranties: 19 per cent moisture, "as received"; 36.49 per cent volatile matter, 0.95 per cent sulphur, 3.5 per cent ash, 12,610 B. t. u., "dry coal." Price, $3.30 per ton (2,000 pounds).

731. Subbituminous coal delivered to Fort Mackenzie, Wyo., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 22 per cent moisture, "as received"; 37.75 per cent volatile matter, 0.71 per cent sulphur, 6 per cent ash, 12,200 B. t. u., "dry coal." Price, $2.25 per ton.

732. Subbituminous coal delivered to the Battle Mountain Sanitarium of the National Home for Disabled Volunteer Soldiers, Hot Springs, S. Dak., 1911–12. Contract guaranties: 4 per cent ash, "dry coal"; 10,000 B. t. u., "as received." Price, $3.30 per ton (2,000 pounds).

733. Bituminous coal delivered to Fort D. A. Russell, Wyo., Quartermaster Corps, War Department, 1913–14. Contract guaranties: 5 per cent moisture, "as received"; 40 per cent volatile matter, 0.8 per cent sulphur, 3.55 per cent ash, 13,500 B. t. u., "dry coal." Price, $5.91 per ton.

734. Bituminous coal delivered to Fort D. A. Russell, Wyo., Quartermaster Corps, War Department, 1914–15. Contract guaranties: 8 per cent moisture, "as received"; 43 per cent volatile matter, 0.85 per cent sulphur, 3.72 per cent ash, 13,500 B. t. u., "dry coal." Price, $5.91 per ton.

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VAN. H. MANNING, Director

EXTRACTION OF GASOLINE FROM NATURAL GAS BY ABSORPTION METHODS

BY

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EXTRACTION OF GASOLINE FROM NATURAL GAS BY ABSORPTION METHODS.

By GEORGE A. BURRELL, P. M. BIDDISON, and G. G. OBERFELL.

INTRODUCTION.

The Bureau of Mines is conducting a series of investigations, with a view to ascertaining the most efficient methods of obtaining gasoline from petroleum and natural gas. This report deals with a method of extracting gasoline from natural gas by absorbing the gasoline in oil and subsequently separating it from the oil by distillation. The process is quite different from those of compression and condensation which have been used for a number of years for extracting gasoline from casing-head natural gas, and has not heretofore been described in the literature.

MANUFACTURE OF GASOLINE FROM CASING-HEAD GAS.

The extraction of gasoline from casing-head natural gas by compression and condensation methods has become a large and lucrative industry in this country. In the year 1915 about 65,000,000[a] gallons of gasoline prepared by these methods was placed on the market. In addition, in marketing this gasoline, at many plants an equivalent quantity of naphtha was blended with the gasoline, thereby utilizing for automobile fuel and other purposes a large quantity of naphtha that otherwise would have been unsuited for these purposes. The increase for the year 1915 over 1914 was about 22,000,000 gallons. For the year 1916 the production should be more than 100,000,000 gallons. The quantity of casing-head gas treated in the year 1915 by compression and condensation methods amounted to about 24,000,000,000 cubic feet; the average yield of gasoline was 2.57 gallons per 1,000 cubic feet.[b] This casing-head gas represents natural gas that formerly went largely to waste; hence the process represented a distinct and important step in the utilization of the natural gas produced in this country.

[a] Northrop, J. D., Natural gas: Press Bulletin 290, U. S. Geol. Survey, October, 1916, p. 1.
[b] Northrop, J. D., loc. cit.

A description of the methods employed in the manufacture of casing-head gasoline and a discussion of tests to determine whether a natural gas contains enough gasoline to warrant the installation of an extracting plant is contained in Bulletin 88[a] and Technical Paper 87.[b]

SUITABILITY OF "DRY" NATURAL GAS FOR MAKING GASOLINE.

By the compression and condensation method, only casing-head gas, or "wet" natural gas, that contains more than one gallon of gasoline per 1,000 cubic feet could be profitably treated. Hence there has been exempted from use in making gasoline not only a large amount of casing-head gas, probably more than one-half the available supply, but also the much larger amount of "dry" natural gas that is used in cities and other places for domestic, factory, and other uses. The quantity of this kind of natural gas consumed in the United States in 1914 amounted to 591,000,000,000 cubic feet.[c]

Much of this "dry" natural gas can be treated by absorption methods. The method consists essentially in bringing the natural gas in contact with an oil heavier than gasoline and letting the oil absorb the gasoline from the gas, and then separating the extracted gasoline from the oil by distillation, or in passing natural gas through naphtha, with a specific gravity of about 50° to 55°, and letting the naphtha absorb as much gasoline as desired, which increases the volume and produces a blend that is intermediate in specific gravity between natural-gas gasoline and the naphtha used.

PRODUCTION OF NATURAL GAS IN 1913 AND 1914.

The quantity and value of natural gas produced in the United States during 1913 and 1914,[d] according to figures by the United States Geological Survey, were as follows:

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[a] Burrell, G. A., Seibert, F. M., and Oberfell, G. G.: The condensation of gasoline from natural gas: Bull. 88, Bureau of Mines, 1915, 106 pp.

[b] Burrell, G. A., and Jones, G. W., Methods of testing natural gas for gasoline content, Tech. Paper 87, Bureau of Mines, 1916, 26 pp.

[c] Northrop, J. D., Natural gas: Mineral Resources of the United States for 1914, U. S. Geol. Survey, 1915, pt. 2, p. 758.

[d] Northrop, J. D., Natural gas: Mineral Resources of the United States for 1914, U. S. Geol. Survey, 1915, pt. 2, p. 751.

Quantity and value of natural gas produced in the United States in 1913 and 1914, by States.

State.	1913			1914		
	Quantity (1,000 cubic feet).	Cents per 1,000 cubic feet.	Value.	Quantity (1,000 cubic feet).	Cents per 1,000 cubic feet.	Value.
West Virginia	245,453,965	13.92	$34,164,650	138,740,162	14.87	$35,515,539
Pennsylvania	118,860,269	18.25	21,698,845	108,494,387	18.80	20,401,295
Ohio	50,612,211	20.79	10,521,950	68,270,174	21.48	14,667,790
Oklahoma	75,017,668	9.91	7,436,389	78,167,414	10.30	8,050,039
Kansas	22,884,847	14.37	3,288,394	22,627,507	14.76	3,340,025
New York	8,515,257	28.50	2,425,633	8,935,187	29.10	2,600,352
Louisiana	26,652,626	7.95	2,119,948	26,774,695	8.32	2,227,999
Alabama						
Texas	12,159,755	17.05	2,073,823	13,483,639	18.38	2,469,770
California	11,034,597	17.07	1,883,450	17,828,928	16.33	2,910,784
Indiana	2,920,614	28.52	843,947	2,579,675	29.28	755.407
Illinois	4,767,128	12.04	574,015	3,547,841	12.32	437.275
Kentucky	1,821,526	27.99	509,946	1,421,818	34.52	490,875
Arkansas	1,106,374	24.35	269,421	962,998	22.23	214,103
Colorado						
Wyoming						
South Dakota	66,492	46.87	31,166	60,781	44.78	27,220
North Dakota						
Missouri	20,365	32.57	6,795	18,085	29.41	5.319
Michigan	1,905	77.84	1,405	2,042	70.61	1,442
Tennessee	2,400	25.00	600	1,200	25.00	300
Iowa	120	100.00	120	200	100.00	200
Total	581,898,289	15.10	87,846,677	591,866,733	15.90	94,115,594

The table shows a production of 591,866,733,000 cubic feet of natural gas for the year 1914, an increase of about 10,000,000,000 over the year 1913.

"DRY" NATURAL GAS AS A SOURCE OF GASOLINE.

All of this gas would not be suitable for making gasoline but most of it would be suitable. Almost all of the natural gas produced in the United States contains members of the paraffin series of hydrocarbons higher than methane. The ordinary combustion analyses of natural gas show only the two predominating paraffin hydrocarbons, which are usually methane and ethane.[a] The authors have never tested natural gas that showed methane and ethane without finding the higher paraffin hydrocarbons, such as propane, butane, pentane, and hexane—when a test was made for them. Most of the gasoline that is obtained by the absorption method comes from pentane and hexane. The so-called "ethane" gas—gas containing ethane and the higher hydrocarbons—constitutes most of the natural gas of this country. Undoubtedly more than 500,000,000,000 cubic feet of such gas is used per year. For instance, all of the natural gas used in Pittsburgh, Buffalo, Columbus, Cincinnati, Cleveland, Louisville, and hundreds of other towns contains ethane.[b] The same is true

[a] Burrell, G. A., and Seibert, F. M., The sampling and examination of mine gases and natural gas: Bull. 42, Bureau of Mines, 1913, p. 77.

[b] Burrell, G. A., and Oberfell, G. G., The composition of the natural gas used in 25 cities in the United States: Tech. Paper 109, Bureau of Mines, 1915, p. 7.

of natural gas produced in Oklahoma, Kansas, California, Texas, and other States. Some natural gas that contains methane as the only paraffin hydrocarbon is found in Louisiana, in the Caddo fields, at a few places in Oklahoma, in the Murrysville sand in Pennsylvania, and at a few other places. This natural gas is the only kind that does not carry gasoline vapors. The natural gas from a new well in which the pressure is high may not carry enough gasoline to warrant the installation of an absorption plant, but most of the natural gas produced in this country undoubtedly can be so treated. If it be assumed that 1 pint of gasoline can be obtained per 1,000 cubic feet of gas, there could be extracted 500,000,000 pints of gasoline from 500,000,000,000 cubic feet of gas, or about 60,000,000 gallons of gasoline per year. If one assumes that 2 pints per 1,000 cubic feet can be obtained the total becomes 120,000,000 gallons per year. Probably 100,000,000 gallons per year would be a conservative estimate. The authors know of one gas company that has under construction enough plants to make 20,000 gallons of gasoline per day. Some of the "dry" natural gas that the authors tested yielded 3 pints of gasoline per 1,000 cubic feet. At 20 cents per gallon the total value of the gasoline saved would be $15,000,000 per year. At 25 cents it would be about $19,000,000 per year, which is about 20 per cent of the total value of the natural gas used in 1914 and probably about 6½ per cent of the total quantity of gasoline consumed in that year.

CONSUMPTION OF GASOLINE.

During the year 1909 the quantity of gasoline consumed in the United States amounted to about 11,000,000 barrels of 42 gallons each; in 1914 the consumption had increased to 30,000,000 barrels, and it is estimated that the consumption in 1916 will be more than 50,000,000 barrels, or more than 2,100,000,000 gallons.

TRANSPORTATION OF NATURAL GAS.

After a gas well has been cased and "shut in" by closing the gate valves on the top of the tubing the well is under control, and the product is ready to be piped to market. Sometimes the rock pressure in a new field is very high, ranging from 600 to 1,000 pounds to the square inch, and it is necessary to reduce the pressure at the well so the gas can be safely turned into the pipe line. This is accomplished by means of reducers that automatically regulate the pressure. In fields that have been drained to such an extent that the rock pressure is very low the pressure in the lines has to be increased. By increasing the pressure, say, to 300 pounds the carrying capacity of a gas line is 21 times greater than at atmospheric pressure. Therefore, it is necessary to build compressing stations, because without them the size and number of mains that would be required to transport the gas from the wells to market would be so large as to make investment impracticable.

As the gas leaves the compressing station it is very hot from being compressed, so that the trunk lines for a short distance from the station are either laid in the bed of a convenient stream or run through a reservoir in order to cool the gas, which is necessary because high temperature reduces the line capacity and has a detrimental effect on coupling rubbers.

The next stopping point for the gas is the measuring and regulating station at the edge of the town, where the pressure is reduced to, say, 50 pounds; it then passes through a medium pressure regulator where it is reduced to 15 to 20 pounds; and a low pressure regulator where it is reduced to 4 to 6 ounces.

EFFECT OF GASOLINE VAPORS ON PIPE-LINE COUPLINGS.

After the gas leaves the compressing station, its capacity for holding gasoline vapors is less because it is compressed, and considerable gasoline is deposited at the cooling station and at various places along the pipe line. The condensation of gasoline in the trunk lines is a constant source of annoyance and expense, because of the action of gasoline on the rubber rings in the patent pipe couplings, which are now universally used on all large pipe lines in place of the old style socket-and-thread "collars." The gasoline softens and decomposes the rubber until it weakens and gives way, causing a "blow-out;" that is, the pipe line will part and let gas escape.

Repairing "blow-outs" is a large item of expense, apart from the large quantities of gas lost. The expense and annoyance from the breaking of a gas line and escape of gas are shown by the recent experience of a large pipe-line company. A report was received at the main office that the pressure on a certain line was falling at the rate of 30 pounds per square inch per hour, although the compressing station reported that the pressure was normal there. Men were immediately dispatched to patrol the line, and discover the leak, which was found about midnight. Twenty-six men worked the rest of the night and the next day in order to repair the line. During this time the pressure had to be raised 70 pounds at the compressing station, and the factory service on the line had to be discontinued.

One company informed the authors that the cost of rubber for couplings used in an 18-inch pipe line 35 miles long, which has transported 100,000,000,000 cubic feet in 10 years, was $16,000. This did not include the cost of placing the couplings or other expense.

Thus it seems that a method for removing the gasoline from natural gas would prolong the life of the couplings, in addition to the fact that a valuable fuel is recovered.

DEVELOPMENT OF THE ABSORPTION PROCESS.

As in the case of condensation and compression methods, the absorption process has assumed industrial importance as the demand for gasoline has increased. The process closely resembles the process

of extracting benzol, toluol, and other products from gas made by the destructive distillation of coal. In the absorption process the gas is caused to flow at about atmospheric pressure countercurrent to a stream of wash oil, which is a petroleum distillate of about 35° Beaumé gravity or a coal-tar distillate such as creosote oil, through absorbing towers 50 to 75 feet high and about 10 to 15 feet in diameter. After the benzol and toluol have been scrubbed from the gas, the charged oil is sent to steam stills where the benzol and toluol are extracted. The process is continuous in that the absorbent oil is used over and over again. The scrubbing process has been used for many years in Germany and to a very large extent in the United States in connection with gas-manufacturing plants and by-products coke plants. Many types of absorbers and steam stills, and different conditions of temperature and pressure were employed before a standard procedure was evolved. The difference between the process of extracting gasoline from natural gas at high pressures and that of extracting benzol and toluol from coke-oven gases is that the absorption of gasoline is conducted at these high pressures, as it is necessary not to disturb the pressure in the pipe-line system.

There might also be mentioned a process in vogue for a number of years past, and practiced at some refineries, of subjecting uncondensed gas and petroleum vapors from stills to absorption in naphtha, thereby increasing the gasoline yield considerably.

Von Groeling's patent [a] covers a process for "Improvements in or relating to the utilization of natural gases or petroleum distillation gases." The claims follow:

(1) A process for the utilization of natural gases or of petroleum distillation gases, consisting in treating the gases at an adjustably increased pressure and adjustably reduced temperature, by quantities determined beforehand, of an absorption medium, for instance of heavy benzine, the unabsorbed gases being then condensed by the use of high pressure and low temperature.

(2) An apparatus for use in carrying out the process set forth in claim 1, in which the gas is treated, in a series of absorption apparatus arranged one behind another, at an adjustably varying increased pressure and adjustably varying reduced temperature, with the absorption medium, so that said absorption medium can circulate through the various absorbers, and the heat absorbed during the expansion of the compressed gases is withdrawn directly from the absorption medium for the purpose of cooling the latter.

(3) A process of the kind set forth in claim 1, in which the gases utilized are first washed at an ordinary temperature and normal pressure with "heavy benzine."

(4) A process of the kind set forth in claim 1, in which the natural gases escaping from a bore hole, or petroleum distillation gases are first heavily compressed, then cooled and finally washed, in the state of exceedingly fine division, with cooled liquid benzine or the like, for the purpose of separating portions of the gas that can be condensed, both the cooling of the benzine required for the washing and the cooling of the gas utilized after the compression being effected with the expanding

[a] Von Groeling, Albrecht, English Patent 30229, issued Dec. 24, 1909.

gases escaping from the absorption column, the gas being finally condensed by the use of high pressure and low temperature.

(5) An apparatus for use in carrying out the process set forth in claims 1, or 4, comprising a column several meters high filled with benzine or the like, into the bottom portion of which the compressed cooled natural gases enter in a state of exceedingly fine division, the upper portion of the column being provided with an expansion valve through which the washed expanded gases pass downwards through an expansion coil or the like, through the washing liquid, for the purpose of cooling the same, and then proceed to the cooling.

(6) A process of the kind set forth in claim 1 for utilizing natural gases or petroleum distillation gases by fractional condensation or absorption, in which the absorption medium is obtained by the preliminary condensation of the gas to be utilized, which is submitted to the gases still noncondensed, the cooling required for the condensation or absorption being obtained by the expansion of compressed gases or by evaporation of already condensed products under a relieved pressure, the gas being finally condensed by the use of high pressure and low temperature.

Saybolt's patent [a] specifies:

(1) That natural gas of the kind supplied to cities be subjected at pressures not less than 30 pounds per square inch to a naphtha-absorbing menstruum and by the aid of the same under high pressure, effecting the separation in industrial quantity from said gas of a natural gas naphtha, liquid at atmospheric pressure and temperature, and applicable to the uses of petroleum naphtha of similar volatility, substantially as described.

(2) The process of obtaining naphtha from combustible gas of natural origin and underground source of the kind supplied by means of wells and pipe lines to the cities for consumption therein, which process consists in subjecting such gas in the requisite large amount on the way from its underground sources to its places of consumption and under a high pressure, not less than 30 pounds per square inch above atmospheric pressure, to a naphtha-absorbing menstruum, especially petroleum or hydrocarbon oil as specified, and by the aid of the same under said high pressure effecting the separation in industrial quantity from said gas, of a natural gas naphtha liquid at atmospheric pressure and temperature and applicable to the uses of petroleum naphtha of similar volatility, and then recovering the naphtha in liquid form from said menstruum by distillation under a low pressure, not more than about atmospheric pressure, substantially as described.

(3) The process of obtaining naphtha from combustible gas of natural origin and underground source of the kind supplied by means of wells and pipe lines to cities for consumption therein, which process consists in subjecting such gas in the requisite large amount on the way from its underground sources to its places of consumption and under a high pressure, not less than about 30 pounds per square inch above atmospheric pressure, to a naphtha absorbing menstruum by causing the gas to bubble up through pools of the menstruum, and by the aid of the same under said high pressure effecting the separation in industrial quantity from said gas of a natural gas naphtha liquid at atmospheric temperature and applicable to the uses of petroleum naphtha of similar volatility, substantially as described.

Hastings and Brink's patent [b] covers an apparatus for removing gasoline from gas under compression, consisting of a reservoir constructed to contain a cooling fluid, a number of headers arranged in the reservoir, cooling pipes connecting the headers, expansion cham-

[a] Saybolt, G. M., U. S. Patent No. 989927, issued Apr. 18, 1911.

[b] Hastings, D., and Brink, A. W., U. S. Patent 867,505, applied for Dec. 10, 1906, issued Oct. 1, 1907.

bers placed in the pipes and of greater diameter than the pipes, means for discharging the liquid condensed in these chambers, and water-spraying tubes, arranged centrally around the pipes, provided with perforations for directing jets of water transversely across the pipes in the path of the stream of gas. The inventors also claim the use of oil instead of water as the separating medium.

Snee's patent [a] specifies a means of providing for the retention of lighter or more volatile oils contained in the product of oil wells, gas wells, and gas wells that produce both oil and gas. The claims follow:

(1) The method herein described consisting in discharging all of the liquid and gaseous hydrocarbon products of an oil well into a liquid and gas container, and absorbing the gaseous hydrocarbons which accumulate within the container above the surface of the liquid.

(2) The method herein described consisting in discharging all of the liquid and gaseous hydrocarbon products of an oil well into a liquid and gas container beneath the fluid level of the latter, and removing and absorbing the gaseous hydrocarbons released from the liquid within the container.

(3) The method herein described consisting in discharging all of the oil from an oil well into an oil and gas container, passing the gaseous products of the well into the oil thus discharged beneath the surface of the latter, and removing and absorbing the gaseous products released from the surface of the oil.

In Koppers' process [b] for extracting naphtha from natural gas the latter is passed under pressure through a solvent oil in a cast-iron bell washer, which is relieved of pressure by placing it within a wrought-iron casing through which gas passes.

To the authors' knowledge, the first large-scale plant for extracting gasoline from natural gas by the absorption method was built at Hastings, W. Va., after extensive experiments by G. M. Saybolt, of the operating company. The plant began operations in 1913. The process consists in causing the natural gas to bubble up through a petroleum distillate of about 35° B. gravity at high pressure, which is then sent to a steam still to separate the gasoline, and is used over and over again. The gas is passed through the absorbing oil at the high pressure of the line. The hot oil from the stills is cooled in a double-pipe cooler or exchanger by the cold oil en route to the still and is further cooled by passing through pipes on which running water falls. The general process, except for the utilization of the gas under high pressure, is identical with the process of absorbing benzol and toluol vapors from coke-oven gases, which has been used for years in Germany and to a large extent during 1915 in the United States.[c]

[a] Snee, John, U. S. Patent 1165458, issued Dec. 28, 1915.

[b] Koppers, H., U. S. Patent 1107808, issued Aug. 18, 1914.

[c] A patent granted to William Young, of Clippens, Renfrewshire, England, on Sept. 7, 1875, describes (Redwood, J. I., Mineral oils and their by-products, 1914, p. 303) a tower with an upper compartment filled with coke to act as a distributing medium. Oil, descending through the coke, mixes with gas traveling upward, and absorbes hydrocarbon vapors. Then, saturated with absorbed hydrocarbon vapors, the oil passes into the lower part of the tower comprising a still, where live or exhaust steam distills off the absorbed vapors. The patentee states that the gases and heavy oils may be brought in contact under pressure. This process, described by Young 42 years ago and covering all hydrocarbon vapors, is identical with the absorption process for natural gas to-day.

OCCURRENCE OF GASOLINE IN NATURAL GAS.

When gas bubbles through or comes in contact with a liquid, it takes up and carries along vapor or minute particles of that liquid. The proportion of vapor that the gas can hold increases as the temperature rises, and is quite independent of the nature of the gas as long as no chemical action takes place. When natural gas in the earth comes in contact with petroleum, those fractions of the petroleum having the lower boiling points will be taken up first, as their vapor pressures are much higher than those of the other fractions. The vapors are carried with the gas in the same manner that water vapor exists with air. The amount of water vapor present in air is principally dependent upon the temperature of the air and the readiness with which the air can obtain the water. If the temperature of air saturated with water vapor be lowered, water vapor will deposit from the air, for air can hold only a certain quantity of water vapor at a particular temperature. Also, if a mixture of air and water vapor that is at a temperature below the critical temperature of water vapor is subjected to pressure, more water vapor can be condensed from the mixture by increasing the pressure. Also, if air containing water vapor be passed through a liquid that absorbs water vapor, it will be removed from the air.

These statements hold true for natural gas that contains gasoline vapor. The gasoline can be removed by compression and condensation, as in the manufacture of casing-head gasoline, or by passing the natural gas through an oil that absorbs gasoline, as in the absorption method.

COMPARISON OF "WET" AND "DRY" NATURAL GAS.

Natural gas is essentially a mixture of gases in which the paraffin series of hydrocarbons predominate, with much smaller proportions of carbon dioxide and nitrogen. Some natural gas contains small amounts of hydrogen sulphide.

"Wet" natural gas contains the higher members of the paraffin series of hydrocarbons in much larger quantity than "dry" natural gas, as is shown by the table following.

It will be observed that there is considerable difference between the two analyses. The "wet" gas, or casing-head gas, represents natural gas that is used for the extraction of gasoline by compression methods; the "dry" gas is typical of several hundred billion cubic feet of natural gas that is used each year in the United States for domestic and industrial uses and from which gasoline can be extracted by the absorption method.

Methane, ethane, propane, and butane are gases at ordinary temperatures. Pentane and hexane are liquids at ordinary temperatures, and are those vapors carried by the gases that constitute most of the gasoline extracted from natural gas. Some butane and, in casing-head

gasoline plants, some propane are also extracted and are chiefly responsible for the "wildness" or high vapor pressure of some gasoline extracted from natural gas by compression and condensation methods.

Casing-head gas represents gas that occurs in contact with oil and hence has an excellent chance to mingle with and carry out of the well some of the lighter vapors—the gasoline of the oil. Furthermore, such natural gas is usually under low pressure. In fact, many oil wells are operated under a vacuum, so that most of the gas has been removed in the past and that being withdrawn consists largely of gasoline vapors. The greater the content of gasoline in the oil and the greater the partial vacuum applied to the well the more gasoline vapor, other things being equal, will be withdrawn from the well.

Results of fractionation analyses of "wet" and "dry" natural gas.[a]

Constituent.	"Dry" gas.[b]	"Wet" gas.
	Per cent.	*Per cent.*
Methane	84.7	36.8
Ethane	9.4	32.6
Propane	3.0	21.1
Butane	[c]1.3	5.8
Pentane, hexane, etc.		3.7
Carbon dioxide	Trace.	Trace.
Nitrogen	1.6	([d])
	100.0	100.0

The "dry" gas, on the other hand, is under pressure ranging from a few pounds to 1,000 pounds per square inch, depending on the well from which it flows. It represents gas that once was in contact with oil or was formed by the same processes that produced the oil. In many cases it represents an escape of lighter hydrocarbons from a sand that contains both oil and gas. Hence the gas carries with it some of the lighter liquid hydrocarbons, or gasoline vapors. In some sands where the gas is under high pressure, however, the gasoline vapors may remain in the gas sand, because of their greater density at that pressure, and only to a slight extent issue with the gas, until the pressure has been relieved to a certain extent. Hence the pressure in a "dry gas" well is one of the factors that determine the gasoline content of the gas. It is possible, however, that even in the case of "dry" natural gas that does not carry enough gasoline to warrant its use in an absorption process such gas may represent a potential gasoline supply that can be obtained when the pressure on the well has been relieved.

[a] Burrell, G. A., Seibert, F. M., and Robertson, I.W., The analysis of natural gas and illuminating gas by fractional distillation at low temperatures and pressures: Tech. Paper 104, Bureau of Mines, 1915, pp. 16, 19.

[b] Combustion analysis showed 79.2 per cent methane, 19.6 per cent ethane, trace of carbon dioxide, and 1.2 per cent nitrogen.

[c] Chiefly butane, includes pentane and hexane.

[d] About 1 per cent.

METHODS OF TESTING NATURAL GAS FOR ITS GASOLINE CONTENT.

Methods in use by the Bureau of Mines for testing natural gas have been described in Bulletin 42[a] and Bulletin 88.[b]

For the purposes required the tests given are satisfactory; but, in order to test natural gas with a view to using it in the absorption process, tests of a different nature had to be devised, because of the small gasoline content in "dry" natural gas. The tests embrace a method that is essentially a laboratory method and another test that can be made in the field by persons who are not chemists.

LABORATORY METHOD.

The method for use in laboratories may be called a freezing method; that is, the gasoline is condensed out of the natural gas and the yield measured. The principle of this method, which has been described in Technical Paper 104,[c] is as follows:

The apparatus shown in figure 1 is exhausted of its air, and the sample of natural gas to be tested is introduced at atmospheric pressure. Next the bulb *b* is surrounded with gasoline that has been cooled to a temperature of about −115° C. by means of liquid air. After the gas has been cooled about 10 minutes, and with the refrigerant still surrounding the bulb, as much gas as possible is removed with a vacuum pump. Next the refrigerant is removed and the gas in the bulb allowed to rise to its original temperature—that is, room temperature. The liquefied gasoline will vaporize and exert pressure on the mercury in the manometer. If the atmos-

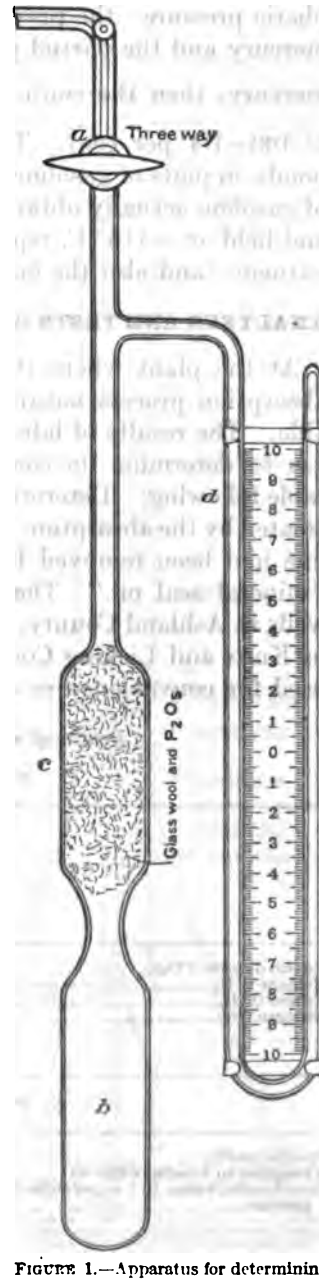

FIGURE 1.—Apparatus for determining gasoline vapor in natural gas.

[a] Burrell, G. A., and Seibert, F. M., The sampling and examination of mine gases and natural gas: Bull. 42, Bureau of Mines, 1913, 116 pp.

[b] Burrell, G. A., Seibert, F. M., and Oberfell, G. G., The condensation of gasoline from natural gas: Bull. 88, Bureau of Mines, 1915, 106 pp.

[c] Burrell, G. A., Seibert, F. M., and Robertson, T. W., Analysis of natural gas and illuminating gas by fractional distillation at low temperatures and pressures: Tech. Paper 104, Bureau of Mines, 1915, p. 26.

pheric pressure—the pressure of the original sample—is 740 mm. of mercury and the partial pressure of the gasoline vapor is 10 mm. of mercury, then the content of gasoline vapor in the sample is $\frac{10}{740} \times 100 = 1.4$ per cent. The authors found that this figure corresponds, in pints of gasoline per 1,000 cubic feet of gas, with the amount of gasoline actually obtained in plant practice. This vapor liquefied and held at $-115°$ C. represents[a] practically all of the gasoline constituents, and also the butane.

ANALYSES AND TESTS OF NATURAL GAS USED IN EXPERIMENTS.

At the plant where the authors conducted their tests with the absorption process natural gas from two different fields was available. The results of laboratory tests that the authors made of this gas to determine its composition and properties are given in the table following. Determinations were made on gas that had not been treated by the absorption process, and also on gas from which the gasoline had been removed by passing it through absorbers containing "mineral seal oil." The gas designated as "line L" gas is from wells in Ashland County, Ohio, and the "low field" gas is from wells in Knox and Licking Counties, Ohio; these terms are local and are used for convenience in designating the two sources of gas used.

Results of tests of fresh and treated natural gas.

COMBUSTION ANALYSIS.

	Fresh natural gas.		Treated natural gas.	
	"Low field" gas.	"Line L" gas.	"Low field" gas.	"Line L" gas.
Carbon dioxide (CO_2)....per cent..	Trace.	Trace.	Trace.	Trace.
Methane (CH_4)....do....	76.3	83.9	79.7	88.3
Ethane (C_2H_6)....do....	18.4	11.7	14.1	7.9
Nitrogen (N_2)....do....	5.3	4.4	6.2	3.8
	100.0	100.0	100.0	100.0

PHYSICAL PROPERTIES.

Specific gravity	0.68	0.63	0.65	0.61
Absorption in Russian white oil[b]	17.0	15.0	16.7	14.0
Gross heating value, B. t. u. per cubic foot at 0° C. and 760 mm. pressure	1,155	1,111	1,111	1,067

GASOLINE CONTENT BY FREEZING METHOD.

Gasoline (butane, pentane, hexane, etc.). pints, per 1,000 cubic feet	1.3	0.8	.....	.....

[a] See Burrell, G. A., and Jones, G. W., Methods of testing natural gas for gasoline content: Tech. Paper 87, pp. 12–14, Bureau of Mines, 1916.

[b] For method of using see absorption by claroline, as described by Burrell, G. A., and Jones, G. W., Methods of testing natural gas for gasoline content; Tech. Paper 87, Bureau of Mines, 1916, pp. 7–10.

COMMENTS ON ANALYSES.

The difference in the natural gas before and after the gasoline has been extracted is interesting. The heating value of the "low field" gas was lowered 44 B. t. u. or 3.8 per cent, the specific gravity dropped from 0.68 to 0.65, and the proportions of paraffin hydrocarbons calculated as methane and ethane were altered. The heating value of "line L" gas was lowered 24 B. t. u., or 2.2 per cent, and the specific gravity dropped from 0.63 to 0.61.

INFERENCE TO BE DRAWN FROM COMBUSTION DATA.

The results in an ordinary combustion analysis of natural gas show only the two predominating paraffin hydrocarbons, usually the methane and ethane. The presence of ethane signifies the presence of higher paraffin hydrocarbons, including gasoline vapors; and it is probable that most natural gas that contains ethane contains enough gasoline to be treated by the absorption process, with the exception, perhaps, of natural gas from new wells under high pressure, and these wells may be potential sources of gasoline that will be produced when the pressure drops sufficiently low.

TESTS WITH SMALL PORTABLE ABSORBER.

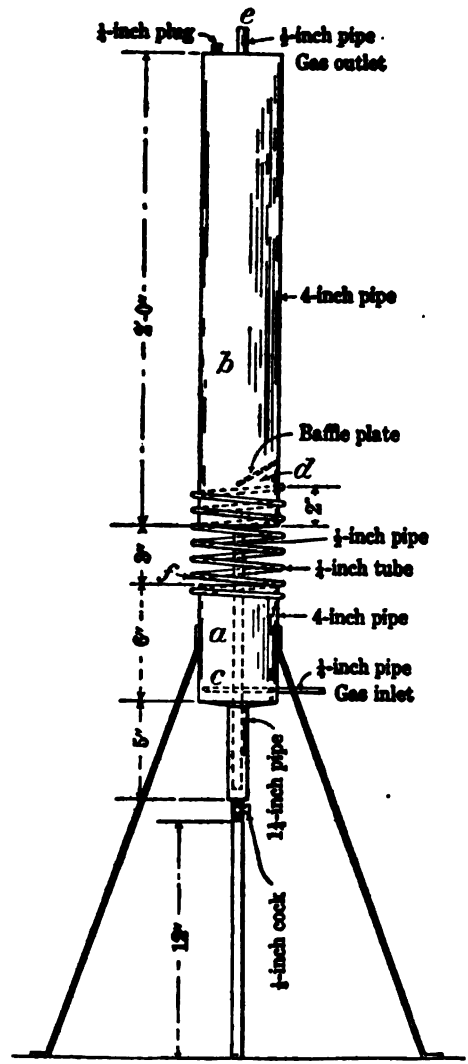

FIGURE 2.—Small absorber for testing natural gas for gasoline content.

A number of tests on a small scale were made with the small absorber shown in figure 2. The absorber, which is built on the principle of a laboratory gas-washing bottle of the Friedrick type, was made of iron pipe and thoroughly welded. It is about 3 feet high, and the two main barrels *a* and *b* were made of 4-inch pipe. The

entering gas bubbles up through the absorbing oil at *c* and passes through the coil of pipe *f* and into the part *d* and out at *e*. This apparatus was designed as a very efficient absorber, to show the maximum possible yield of gasoline from natural gas.

In passing natural gas with its gasoline vapor through an absorbent oil, there will occur a point in the solution process when a particular oil will not take up any more gasoline. In tests by the authors with "mineral seal oil" the saturation point of this oil was determined to be 28 per cent. In conducting the tests natural gas was passed through the oil, using the small absorber shown in the figure, until no more gasoline was absorbed by the oil. By a saturation of 28 per cent is meant that the gasoline content was 28 per cent of the total volume of gasoline and oil.

In practice, however, the percentage of the gasoline absorbed in the oil should not be carried that far. Tests showed that when the absorption of gasoline exceeded 4 per cent, some of the gasoline in the natural gas passing through the oil was not extracted and passed out with the gas. As the percentage was increased and more gasoline was absorbed, an increasingly small amount appeared in the exit gases, which was always less than the amount absorbed until the saturation point, 28 per cent, was reached, when the percentage in the entering gas was equal to the percentage in the gas given off, that is, no more gasoline was being absorbed.

Therefore in all tests made both on the small absorbers and on the larger experimental plants, a close watch was kept on the percentage of the gasoline in the absorbent. This can be regulated by adjusting the feed of gas and the amount of oil used.

OILS USED IN TESTS.

Two different oils were used as the absorbing medium in these tests. One of them was the "mineral seal oil" used in the previous tests, the other, known as "straw oil," was also a petroleum distillate. Their characteristics as determined by E. W. Dean, petroleum chemist of the Bureau of Mines, were as follows:

Characteristics of oils used as absorbents.

"MINERAL SEAL OIL."

Flash point (Pensky-Martin closed apparatus)	135° C., 275° F.
Burning point (Pensky-Martin open apparatus)	160° C., 320° F.
Specific gravity (Water=1)	0.850

First drop distilled at 225° C. (437° F.); 6.2 per cent was distilled on heating to 275° C. (527° F.).

"STRAW OIL."

Flash point (Pensky-Martin closed apparatus)	183° C., 361° F.
Burning point (Pensky-Martin open apparatus)	208° C., 406° F.
Specific gravity (Water=1)	0.851

First drop distilled at 250° C. (482° F.); vapor began to distill in quantity at 275° C. (527° F.).

RESULTS OF TESTS OF NATURAL GAS WITH SMALL ABSORBER.

The results of tests of "low field" and "line L" natural gas with "mineral seal" oil and absorbers of the type shown in figure 2 are given in Table 1. Three of these absorbers, designated as Nos. 1, 2, and 3 in Table 1, were connected in series. The natural gas passed through absorbers 1, 2, and 3, in the order mentioned, then through a small domestic gas meter where the gas flow was measured. The gas was passed through the oil under a pressure of 235 pounds per square inch. Other data given in the table are: (1) Rate of flow of gas per hour; (2) cubic centimeters of oil used; (3) cubic feet of gas used; (4) temperature of oil; (5) cubic centimeters of oil and gasoline recovered; (6) absorption of gasoline in the oil, per cent; (7) amount of sample taken from absorber at end of test in order to make a distillation test; (8) amount of gasoline obtained from oil sample by distillation; (9) amount of gasoline from oil sample, calculated to represent all the gasoline in the oil; (10) boiling points of the extracted gasoline; (11) cubic centimeters of oil used in the test per 1,000 cubic feet of gas; (12) pints of gasoline obtained in each absorber for each 1,000 cubic feet of gas used; (13) gravity of the extracted gasoline, degrees Baumé; (14) total amount of gasoline obtained from the three absorbers.

The reader should note that in this report the terms "gravity" and "specific gravity" are both applied to degrees Baumé, although strictly speaking neither application is correct. Oil men generally use the term "gravity," but the Baumé scale is a hydrometric scale and measures the density of a liquid.

TABLE 1.—*Results of gasoline extraction tests*

[Pressure in absorber, 235

"MINERAL SEAL OIL

Item.	"Low field" gas.								
	Test 1.			Test 2.			Test 3.		
Date of test	Jan. 10, 1916.			Jan. 10, 1916.			Jan. 12, 1916.		
Number of absorber	1	2	3	1	2	3	1	2	3
Rate of flow of gas, cubic feet per hour	360	360	360	240	240	240	190	190	190
Oil used, c. c	1,750	1,500	1,500	1,750	1,500	1,500	1,750	1,500	1,500
Gas used, cubic feet	202	202	200	200	200	200	200	200	200
Temperature of oil, ° F	58	60	62	60	60	64	70	73	73
Oil and gasoline recovered, c. c	1,960	1,580	1,550	1,980	1,600	1,570	1,990	1,600	1,570
Absorption of gasoline, per cent [a]	7.9	2.3	.4	7.0	2.1	.2	6.9	1.4	.04
Sample taken for distillation test, c. c	650	527	517	660	533	523	663	533	523
Gasoline obtained from sample by distillation, c. c	45	12	2	46	11	1	45.5	7.5	.2
Total gasoline recovered in test, c. c. [a]	135	36	6	138	33	3.0	136.5	.6	
Oil used per 1,000 cubic feet of gas, c. c	8,750	7,500	7,500	8,750	7,500	7,500	8,750	7,500	7,500
Gasoline from each absorber, pints per 1,000 cubic feet of gas	1.42	.36	.06	1.46	.35	.03	1.44	.24	.01
Specific gravity of gasoline, ° B	84			84			85		
Boiling point of gasoline, ° F	110–250	150–250	150–250	110–250	145–250	150–250	130–250	145–250	
Total gasoline from three absorbers, pints per 1,000 cubic feet of gas	1.84			1.84			1.69		

"STRAW OIL" USED

Item.	"Low field" gas.					
	Test 11.			Test 12.		
Date of test	Jan. 10, 1916.			Jan. 12, 1916.		
Number of absorber	1	2	3	1	2	3
Rate of flow of gas, cubic feet per hour	106	106	106	100	100	100
Oil used, c. c	1,750	1,500	1,500	1,750	1,500	1,500
Gas used, cubic feet	100	100	100	200	200	200
Temperature of oil, ° F	63	64	64	68	68	68
Oil and gasoline recovered, c. c	1,890	1,540	1,515	1,905	1,570	1,550
Absorption of gasoline, per cent	3.7	.2	0	5.8	1.1	.5
Sample taken for distillation test, c. c	630	513	503	635	523	310
Gasoline obtained from sample by distillation, c. c	23	1.0	0	37	6	1.5
Total gasoline recovered, c. c	69	3		111	18	7.5
Boiling point of gasoline, ° F	114–260	172–250		110–280	120–270	136–260
Specific gravity of gasoline, ° B				85.7		
Gasoline from each absorber, pints per 1,000 cubic feet of gas	1.46	.06		1.17	.19	.08
Total gasoline from three absorbers, pints per 1,000 cubic feet of gas	1.52			1.44		

[a] Calculated on total quantity of oil and gasoline.

of natural gas with small absorption plant.

pounds per square inch.]

USED AS ABSORBENT.

"Low field" gas—Continued.												"Line L" gas.			
Test 4.			Test 5.			Test 6.			Test 7.			Test 8.		Test 9.	Test 10.
Jan. 12, 1916.			Jan. 12, 1916.			Jan. 4, 1916.			Jan. 4, 1916.			Jan. 1, 1916.		Jan. 1, 1916.	Jan. 1, 1916.
1	2	3	1	2	3	1	2	3	1	2	3	1	2	2	1
190	190	190	50	50	50	89	89	89	159	159	159	88	88	94	91
1,750	1,500	1,750	1,750	1,500	1,500	1,750	1,500	1,500	1,750	1,500	1,500	1,750	1,500	1,500	1,500
100	100	100	200	200	200	200	200	200	200	200	200	50	50	100	100
65	66	66	66	68	68	57	57	58	57	58	56	50	49	53	50
1,870	1,545	1,535	1,945	1,555	1,555	2,035	1,650	1,650	2,000	1,600	1,570	1,865	1,540	1,590	1,610
3.9	.8	.04	7.3	1.6	.4	7.2	2.2	.2	8.1	2.4	.6	1.8	0	3.6	3.4
623	515	512	648	518	518	806	550	780	800	533	785	622	770	795	537
24	4	.2	47.5	8.5	2.0	36.5	12.0	1.7	40.5	12.8	5.0	11.0	0	28.2	18
72	12	.6	142.5	25.5	6	146	36	34	162	38.4	10	33	0	56.4	54
17,500	15,000	15,000	8,750	7,500	7,500	8,750	7,500	7,500	8,750	7,500	7,500	35,000	30,000	15,000	15,000
1.52	.25	.....	1.50	.27	.06	1.54	.38	.04	1.71	.41	.11	1.40	0	1.19	1.14
						83.7			84						
120–250	145–250	.....	110–250	125–250	.....	110–260	110–254	100–250	116–250	116–250	106–250	125–240	.....	130–270	130–260
1.78			1.84			1.96			2.23			1.40		1.19	1.14

AS ABSORBENT.

"Low field" gas—Continued.			"Line L" gas.								
Test 13.			Test 14.			Test 15.			Test 16.		
Jan. 20, 1916.			Jan. 19, 1916.			Jan. 19, 1916.			Jan. 20, 1916.		
1	2	3	1	2	3	1	2	3	1	2	3
106	106	106	200	200	200	195	195	195	55	55	55
1,750	1,500	1,500	1,750	1,500	1,500	1,750	1,500	1,500	1,750	1,500	1,500
400	400	400	400	400	400	400	400	400	200	200	200
62	63	63	60	60	60	55	52	50	68	70	70
1,995	1,615	1,540	1,925	1,540	1,550	1,860	1,620	1,560	1,850	1,570	1,540
9.4	3.9	1.6	5.5	3.9	1.1	6.5	3.1	1.3	4.2	1.1	.1
658	538	308	642	513	517	620	540	520	617	523	513
62	21	4.8	35.5	20	5.9	40.5	16.5	7.0	26	6	.5
186	63	24	107	60	17.7	121.5	49.5	21.0	78	18	1.5
96–340	130–300	144–290	94–290	110–280	165–275	113–300	130–295	160–290	118–290	130–275	210–260
83.1	.....	.....	.54	.32	.09	.64	.26	.11	.82	.18	.02
.98	.33	.13	79.3	.....	.....	80.8	.....	.....	83.5	.....	.....
1.44			0.95			1.01			1.02		

COMMENT ON RESULTS OF TESTS.

After each test was finished, a small sample (about 500 c. c.) of the oil was distilled and the yield of gasoline measured. The total quantity of gasoline in the oil was calculated from the quantity obtained from this small sample. The yield in pints of gasoline per 1,000 cubic feet of gas was calculated from this data and from the amount of natural gas used in the test In general, when the percentage of gasoline absorbed in the oil was high in the first absorber, it was high in the second one.

Tests 1 to 7, with "low field" gas, show that in the small absorbers used a yield of gasoline varying from 1.77 pints to 2.23 pints per 1,000 cubic feet of gas could be obtained. Most of the gasoline was extracted in the first absorber, and the rest in the second, practically no gasoline being obtained in the third. In other words absorption was practically complete with two absorbers. The absorption percentage, 7 to 8 per cent, was allowed to rise too high in the first absorber to extract all the gasoline in one absorber.

The yield of gasoline from the "line L" gas, tests 8 to 10, was less than from the "low field" gas. In test 8 two absorbers were used in series but for tests 9 and 10 only one absorber was used. The absorption of gasoline was kept down to about 2 to 4 per cent, so that one absorber would extract all the gasoline, by using a smaller quantity of gas in the tests.

Tests 11 to 16 show the results obtained from "line L" and "low field" gas with "straw oil" as the absorbent. The yields were not quite as high as those obtained with "mineral seal oil."

In using one absorber for field tests it is recommended that about 100 cubic feet of gas be used at the rate of 100 cubic feet per hour, with 1,750 c. c. of oil.

LARGE-SCALE EXPERIMENTAL PLANT AND ITS OPERATION.

While the tests with the small-scale absorber were under way, tests on a much larger scale were made with the plant shown in figure 3. This plant was capable of continuous operation as natural gas was continuously passed through the absorbing oil, and the oil, after leaving the absorbers charged with gasoline, was pumped to steam stills, where the gasoline was removed and the oil pumped back to the absorbers to receive another charge of gasoline. The plant had a capacity of 15,000 to 30,000 cubic feet per hour.

CIRCULATION OF GAS AND OIL.

The natural gas, which is brought in from a pipe line, enters the absorbing tank at *c* and the oil enters at *b*. They pass into the T pipe *d*, and the mixture passes from there through many small holes

into the oil contained in the absorber. The gas bubbles up through the oil and passes out of the absorber as shown and returns to the pipe line.

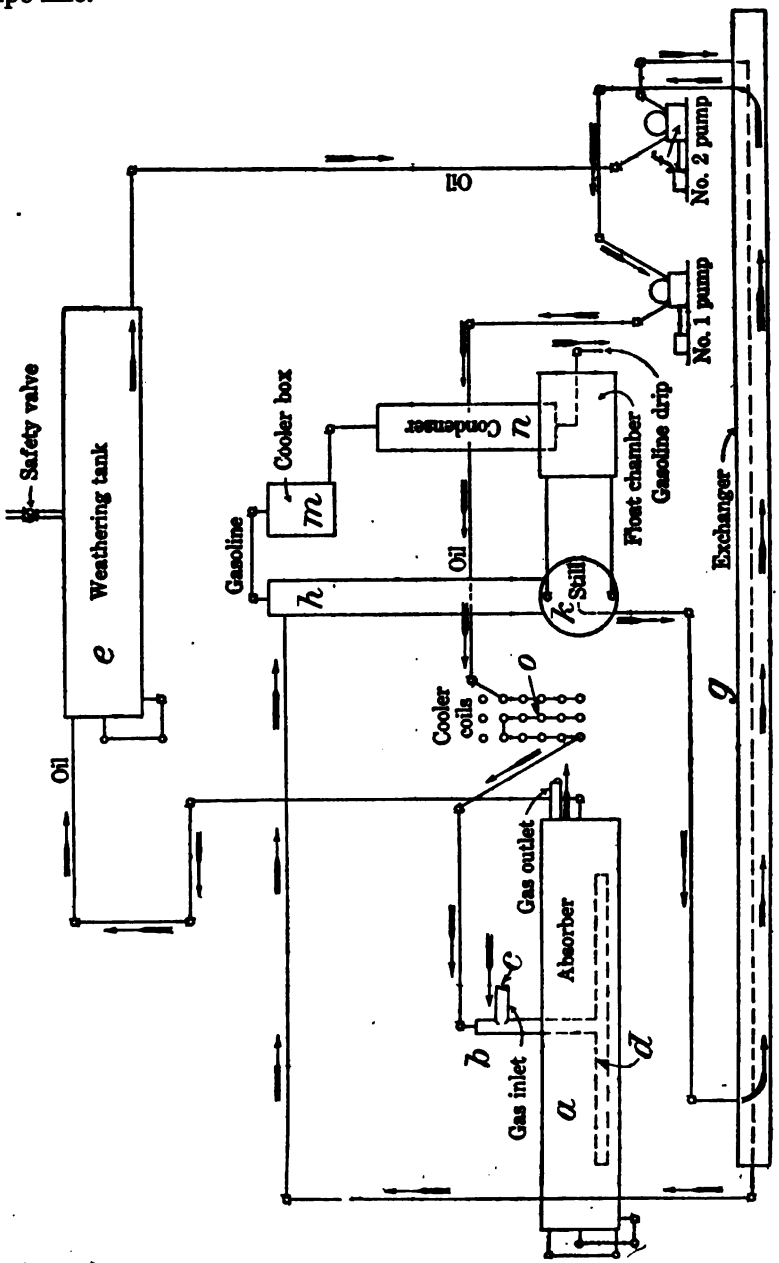

FIGURE 3.—Experimental plant for absorbing gasoline from natural gas.

The oil charged with gasoline passes first to the weathering tank *e*, where the lighter parts of the gasoline are released through the safety valve. Next the oil enters the pump *f* and is pumped through the

heat exchanger *g* into the rock tower *h* of the steam still *k*, where the gasoline is distilled from the oil with live steam. The cooler *m* separates the water (condensed steam) from the gasoline, which is condensed in the condenser and flows out of the system at the gasoline drip.

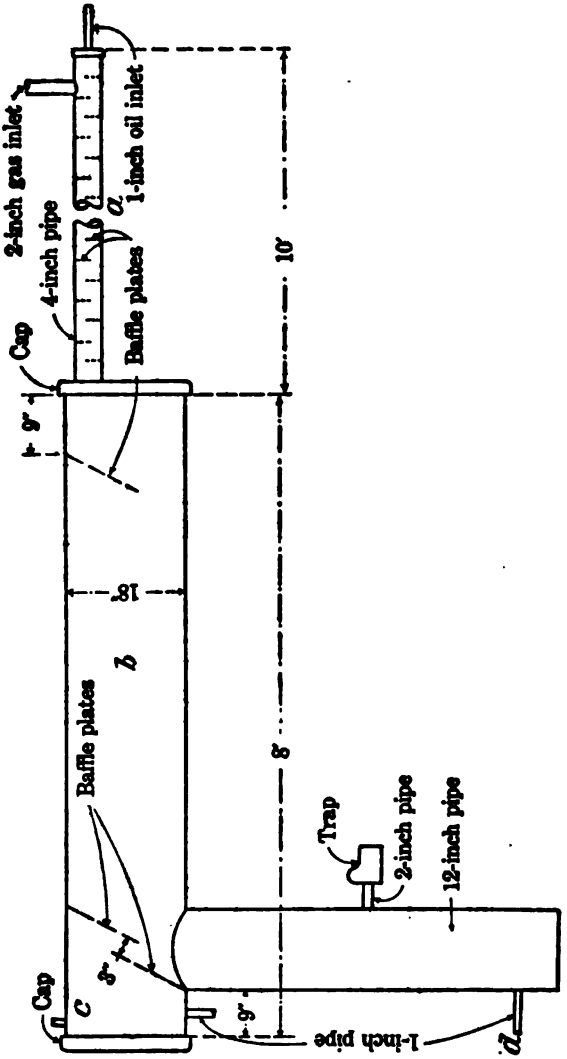

FIGURE 4.—Horizontal absorber, with baffle plates.

The hot oil, after having been freed of its gasoline, is passed through the heat exchanger *g* and heats the oil passing to the still and from No. 1 pump is forced through the cooling coils *o*, on which running water drops. The cooled oil then passes into the absorber *a* to receive another charge of gasoline. The operation is continuous, the oil being used over and over again.

ABSORBERS.

In addition to the type of absorber shown in figure 3 and in detail in figure 6, two other types of absorbers were used as shown in figures 4 and 5. In the absorber (No. 4) illustrated in figure 4 the gas and oil enter as shown, splash together against the baffle plates, and pass through the pipe *a* into the main pipe *b*. The gas leaves the absorber at the point *c*, and the oil, charged with gasoline, leaves at the point *d*. In the vertical or tower absorber (No. 5), illustrated in figure 5, the oil enters as shown and drops onto and through a column of stones each about the size of a man's fist. The gas enters near the base of the tower and flows countercurrent to the oil and out of the gas pipe at the top of the column. In the horizontal absorbing chamber (No. 6), shown in figure 6, the oil and gas flow through a vertical pipe and along a horizontal perforated pipe near the bottom of the chamber, whence the gas rises through the oil.

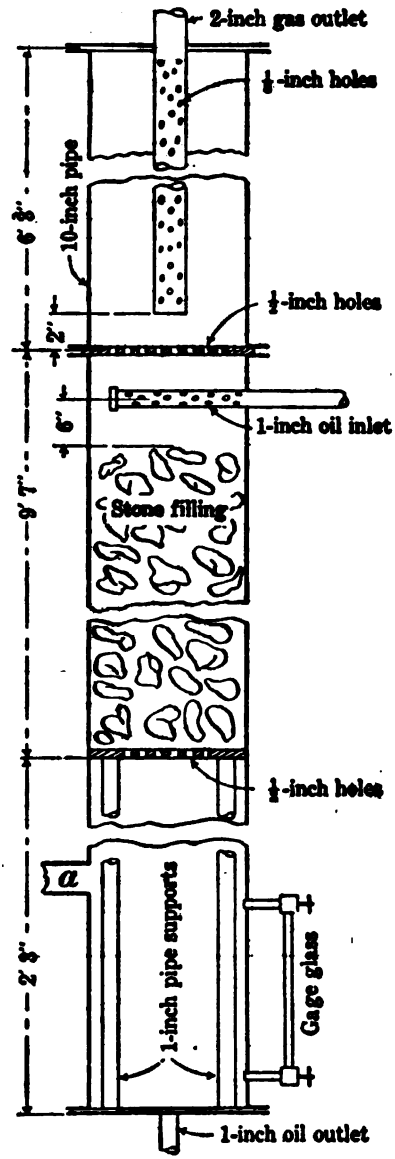

FIGURE 5.—Tower absorber, filled with stones.

The steam still used in the tests is shown in figure 7. The oil charged with gasoline entered at the top of the stone column *a;* live steam entered the still through the T pipe *b*. The oil, freed of its gasoline, left the still at *c*.

REMOVAL OF GASOLINE.

The cooling box in which the steam in the gasoline was condensed and the water returned to the still is shown in figure 8. The condensed steam was returned to the still at *a;* the gasoline vapors passed through *b* to the cooler.

Figure 9 shows the condenser where the gasoline vapors were condensed and removed from the system.

The heat exchanger used in the experiments is shown in detail in figure 10. The oil flowing from the absorber to the still passed

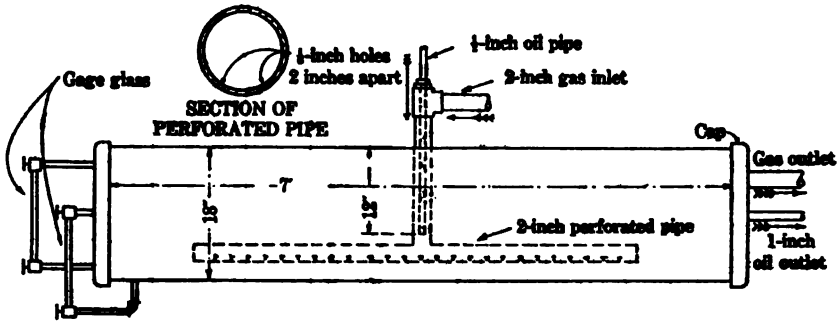

FIGURE 6.—Horizontal absorber, in which gas bubbles through the oil.

through the inside pipe and was heated by the hot oil from the still which passed through the outside pipe. The coils over which water

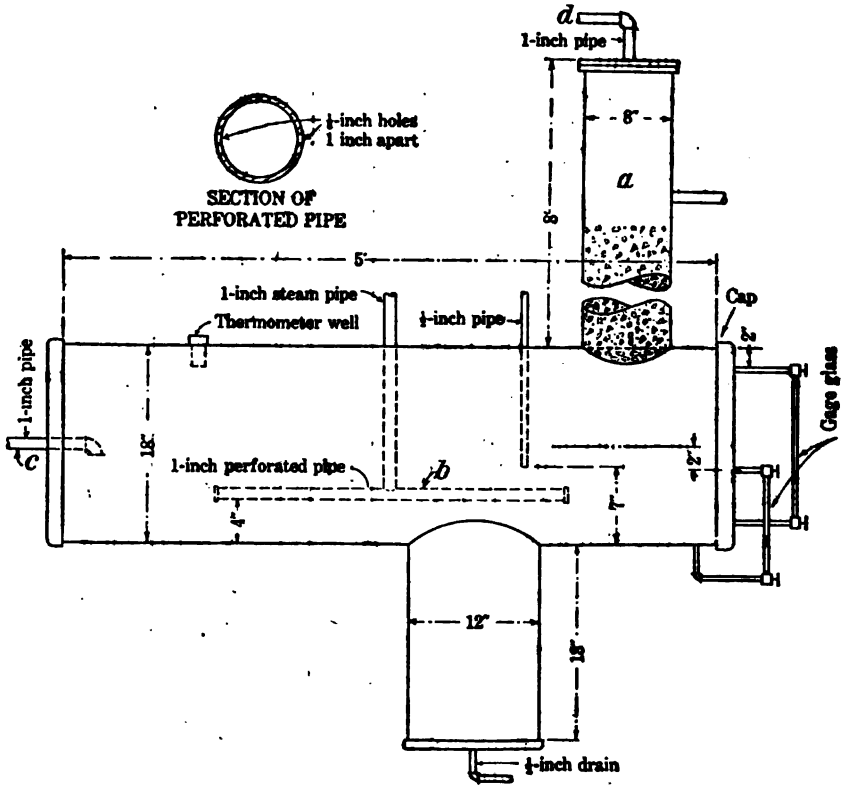

FIGURE 7.—Steam still for removing gasoline from absorbent.

flowed to cool the hot oil before it passed again into the absorber are shown in figure 11.

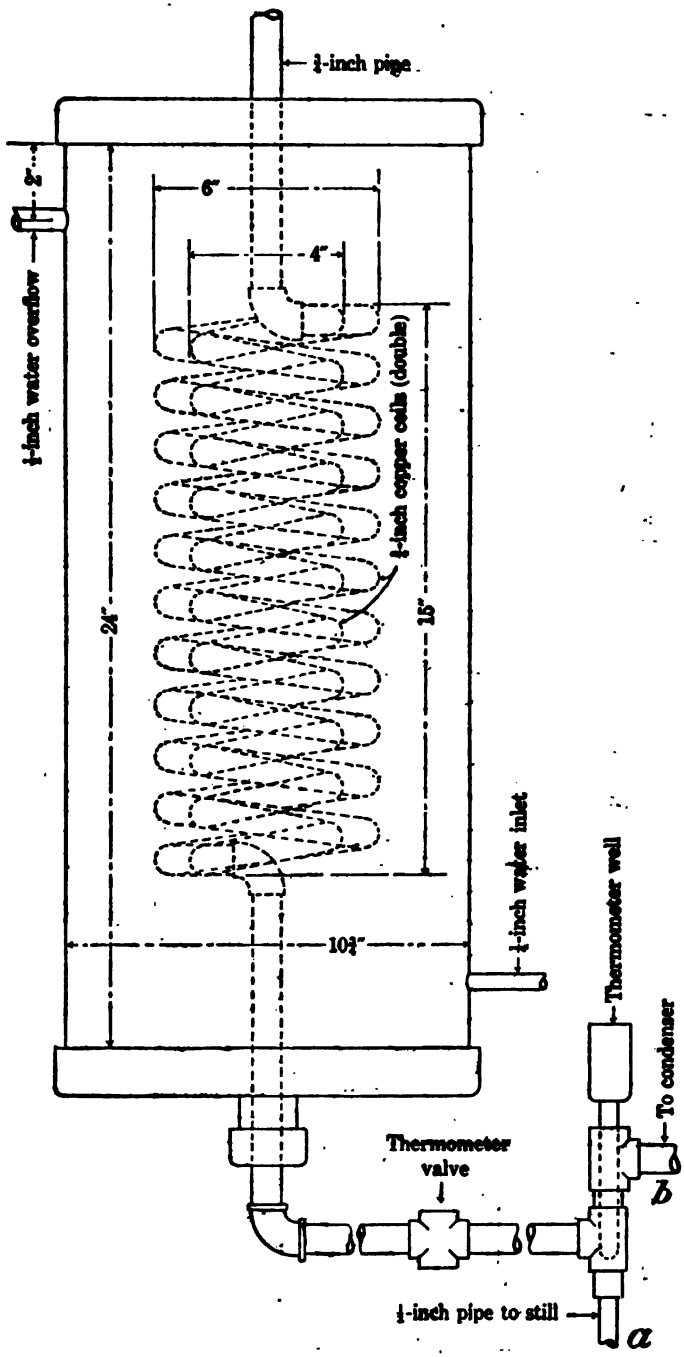

FIGURE 8.—Cooler box of condensing still.

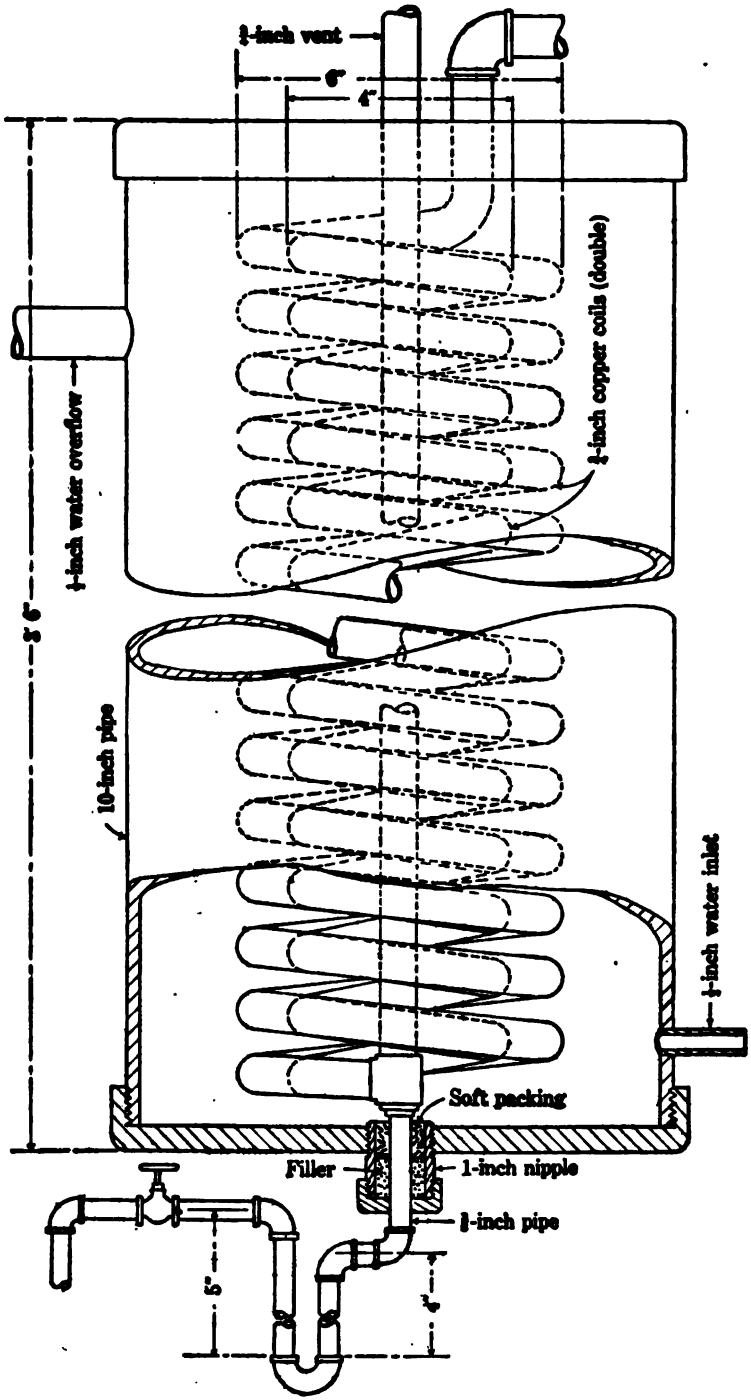

FIGURE 9.—Condenser for removing gasoline.

The weathering tank, where the lighter constituents of the gasoline were permitted to escape through a relief valve, is shown in figure 12.

REGULATION OF OIL FEED.

Oil in the still could not exceed a certain height because of the float shown in figure 13. When the oil exceeded the proper level, the ball *a* was raised, opening a valve *b* and allowing oil to flow from the still to a pump and from there around the circuit.

RESULTS OF TESTS WITH HORIZONTAL ABSORBERS.

Table 2 shows the results of tests with different absorbers on "low field" natural gas and "line L" natural gas. Each test was of four hours' duration and was conducted at the pressure of the gas line, about 225 pounds per square inch. In the first four tests more gaso-

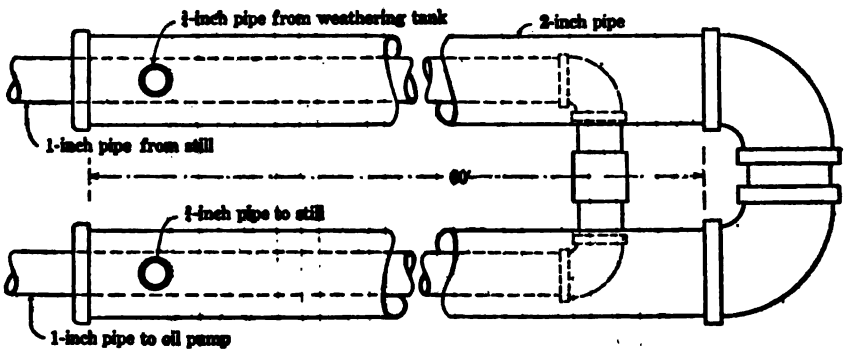

FIGURE 10.—Heat exchanger.

line was obtained from "low field" gas with absorber No. 2 than when absorber No. 4 was used. The same is true of "line L" gas, although in both cases the difference is slight. The pressure on the still was kept at about 2 to 3 pounds per square inch. The gas as it came from the lines had a temperature of about 46° to 53° F. The oil, after it left the stills and was cooled by passing through pipes upon which running water fell, had a temperature of about 80° F. The temperature of the oil charged with gasoline, after it had been heated in the "heat exchanger" and before it entered the still, was about 120° to 140° F. The "heat exchanger" heated the oil before it entered the still from a temperature of about 60° to 70° F. to a temperature of about 120° to 140° F.

In test 6, to show the effect of high temperature of the absorbing oil in decreasing the gasoline yield, the oil was given a temperature of about 90° F., which was about 10° higher than the previous tests, This rather slight increase in temperature made an appreciable dif-

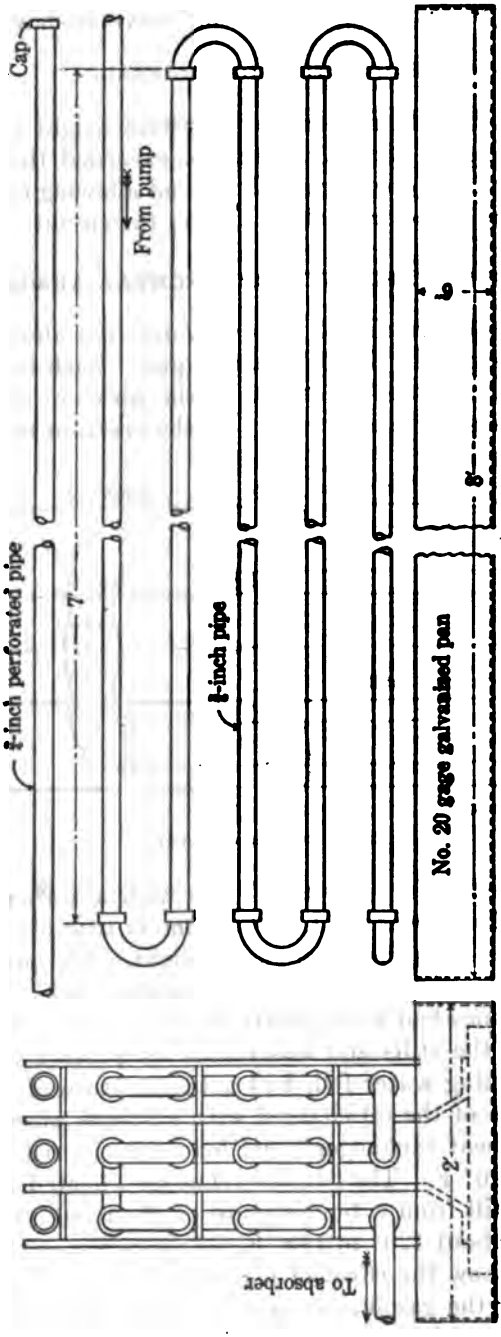

FIGURE 11.—Coils for cooling the hot oil from the still.

ference in the yield, as it was decreased about 0.3 pint of gasoline per 1,000 cubic feet of gas.

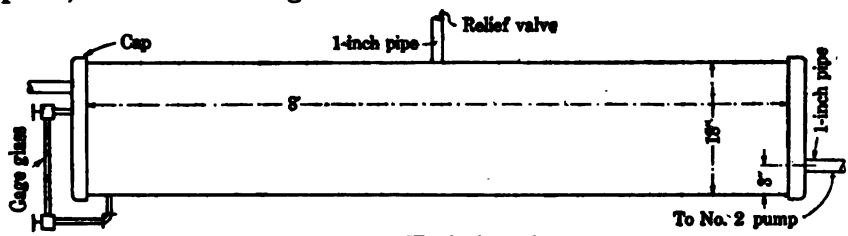

FIGURE 12.—Weathering tank.

The three different kinds of absorbers used in the tests are given the same numbers (Nos. 4, 5, and 6) as the illustrations that show

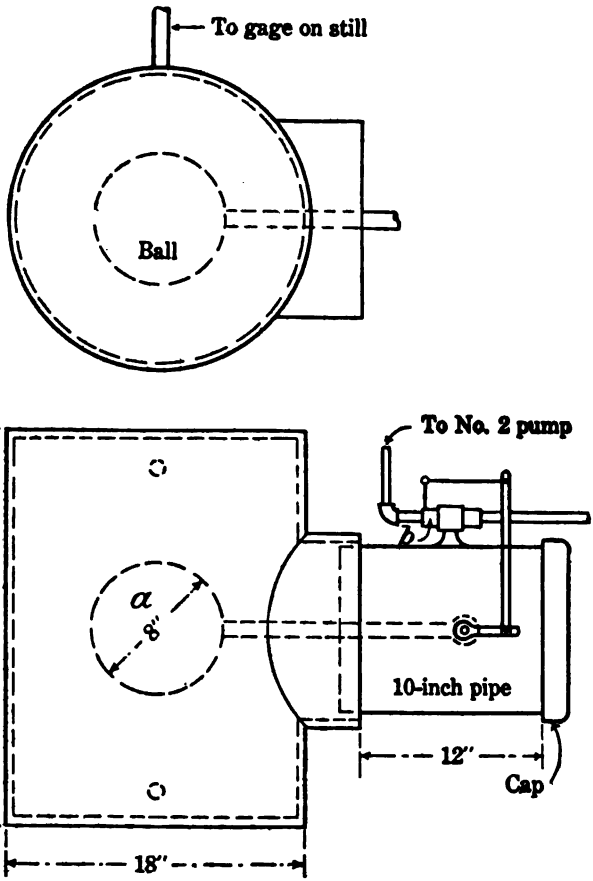

FIGURE 13.—Float for controlling height of oil in still.

them in detail (see figs. 4, 5, and 6). Figure 3 shows the plant as equipped with absorber 6. In each case it will be observed that greater yields of gasoline were obtained when absorber 5 was used.

TABLE 2.—*Data on continuous extraction of gasoline from natural gas with experimental plant.*

Item.	"Low field" gas.									
	Test 1.					Test 2.[a]				
Absorber No.	6					4				
Date of test	Jan. 28, 1916.					Jan. 29, 1916.				
Time	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.
Pressure at inlet to absorber, pounds per square inch	.....	.....	239.4	.....	.....	.....	.....	219.4	.....	.....
Pressure on still, pounds per square inch	3	3	3	2	3	2.5	2.5	2.5	2.5	2.5
Temperatures, ° F.:										
Gas inlet to absorber	52	54	52	54	56	50	50	50	50	50
Oil inlet to absorber	74	79	79	79	79	84	82	78	74	76
Oil inlet to still	134	124	144	138	122	126	118	124	124	142
Oil outlet from still	208	208	209	208	208	210	210	210	210	210
Vapor outlet from still	210	208	209	212	210	208	206	206	206	206
Vapor outlet from cooler	154	168	164	162	154	172	170	170	170	174
Cooling water	52	52	52	52	52	52	52	52	52	52
Still	216	215	216	215	216	216	216	216	216	216
Oil outlet from absorber	65	70	70	70	70	76	62	67	70	70
Specific gravity of absorbing oil, ° B.:										
At inlet to absorber	34.9	33.6	33.6	33.6	33.6	35.1	35.3	35.6	35.9	35.9
At outlet from absorber	37.7	37.2	37.2	37.6	37.6	35.8	36.9	36.5	36.2	36.5
Yield of gasoline, c. c.	.....	9,000	9,500	9,600	10,000	.....	9,800	9,900	10,500	10,200
Specific gravity of gasoline, ° B	.....	82.1	82.5	82.3	82.3	.....	81.7	81.4	81.4	81.7
Amount of gas passed, cubic feet			63,000					60,000		
Yield of gasoline per 1,000 cubic feet, pints			1.2775					1.420		
Rate of gas flow, cubic feet per hour			15,750					15,000		
Rate of oil flow, gallons per 1,000 cubic feet of gas			9.1					7.1		
Absorption percentage			3.7					.....		

Item.	"Line L" gas.									
	Test 3.					Test 4.				
Absorber No.	6					4				
Date of test	Jan. 24, 1916.					Jan. 19, 1916.				
Time	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	9 a. m.	10 a. m.	11 a. m.	12 m.	1 p. m.
Pressure at inlet to absorber, pounds per square inch	219						233			
Pressure on still, pounds per square inch	2	2	2	2	2	2	2	2.5	2.75	2
Temperatures, ° F.:										
Gas inlet to absorber	52	52	50	52	52	.....	43	48	48	48
Oil inlet to absorber						76	80	78	78	64
Oil inlet to still						114	122	120	120	120
Oil outlet from still	208	176	210	198	198	212	212	212	212	212
Vapor outlet from still	210	212	214	214	212	208	210	208	210	210
Vapor outlet from cooler	170	186	184	156	144	162	160	158	158	160
Cooling water	52	52	52	52	52	.....	58	58	58	58
Still	214	214	216	214	214	216	216	216	216	216
Oil outlet from absorber						62	62	62	62	62
Yield of gasoline, c. c.	.....	5,500	6,200	4,700	6,250	.....	6,080	6,000	5,570	5,300
Specific gravity of gasoline, ° B							79.9	80.6	80.6	79.6
Amount of gas passed, cubic feet			62,920					61,600		
Yield of gasoline per 1,000 cubic feet, pints			759					819		
Rate of gas flow, cubic feet per hour			15,730					15,400		
Rate of oil flow, gallons per 1,000 cubic feet of gas			5.13					8.4		

[a] This test was made with full-line pressure.

TABLE 2.—*Data on continuous extraction of gasoline from natural gas with experimental plant*—Continued.

Item.	"Low field" gas.									"Line L" gas.								
	Test 5.[b]									Test 6.[b]								
Absorber No.	4									6								
Date of test	Jan. 27, 1916.									Jan. 27, 1916.								
Time	8 a.m.	9 a.m.	10 a.m.	11 a.m.	12 m.	1 p.m.	2 p.m.	3 p.m.	5 p.m.	8 a.m.	9 a.m.	10 a.m.	11 a.m.	12 m.	1 p.m.	2 p.m.	3 p.m.	4 p.m.
Pressure at inlet to absorber, pounds per square inch				241.4										244.7				
Pressure on still, pounds per square inch	2	3	2	3	2.5	2.5	2.75	2.75	2.5	3	3	3	3	2.5	2.75	3	2	3
Temperature, ° F.:																		
Gas inlet to absorber	46	46	46	46	46	46	46	46	46	46	60	60	61	62	62	64	63	62
Oil inlet to absorber	82	80	86	82	86	84	86	88	88	87	97	92	99	80	80	88	90	92
Oil inlet to still	122	128	134	128	128	126	126	144	144	130	132	130	139	139	132	132	138	144
Oil outlet from still	210	210	210	210	210	210	210	210	208	208	210	208	208	208	207	206	209	210
Vapor outlet from still	208	210	208	206	204	208	208	208	208	217	214	212	212	214	208	206	211	212
Vapor outlet from cooler	166	170	168	164	168	168	158	168	168	190	192	166	182	156	146	162	200	184
Cooling water	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73
Still	216	218	216	216	216	216	216	216	216	217	218	216	216	214	214	214	216	216
Oil outlet from absorber	.....	76	77	77	78	78	76	80	80	.....	77	72	76	78	77	84	86	86
Specific gravity of absorbing oil, ° B.:																		
At inlet to absorber	.....	34	33.9	33.9	33.9	34.2	34	33.9	33.9	.....	35.1	35.1	35.0	33.5	33.9	35.6	35.5	35.6
At outlet from absorber	.....	35.8	35.7	35.7	34.6	34.6	34.8	34.5	34.6	.....	37.2	37.1	36.8	36.6	37.6	36.1	36.9	36.9
Yield of gasoline, c. c.	.....	6,750	7,850	9,250	8,750	9,300	10,250	8,300	8,100	.....	6,000	6,500	8,130	6,100	7,750	9,100	7,250	7,200
Specific gravity of gasoline, ° B	.....	87.5	91.6	89.6	91.5	91.5	91.6	91.6	91.5	.....	77.0	78.7	78.6	78.7	78.6	78.0	78.6	78.6
Amount of gas passed, cubic feet	121,800									123,500								
Yield of gasoline, pints per 1,000 cubic feet	1.182									0.993								
Rate of gas flow, cubic feet per hour	15,200									15,425								
Rate of oil flow, gallons per 1,000 cubic feet of gas	5.3									8.8								
Absorption percentage	2.6									2.2								

[b] This test was made to determine the absorbing power of oil at a high temperature.

TESTS WITH TOWER ABSORBER.

With the experimental plant a number of tests were made in which the tower absorber (No. 5) shown in figure 5 was used. The results are given in Table 3, with those of a test made on the same day with absorber 4, shown in figure 4. The results are much in favor of the tower absorber. In fact, an arrangement like that shown in figure 5 has been found, from long experience by technical gas men, to be the most efficient method of washing or scrubbing any gas, although there are various other methods of introducing a spreading or contact surface, such as the use of clay tile or wooden lattice work.

The oil enters above the stones and flows through the interstices between them, covering each pebble with a thin film and exposing a large surface to the rising gas. The gas enters near the bottom of the absorber and first encounters oil more or less charged with gasoline. Some gasoline is removed from the gas at the start, and more is removed as the gas travels upward. Finally the gas, almost stripped of its gasoline, comes in contact with fresh oil which absorbs the remaining portions of the gasoline from the gas. The results of these tests are shown in Table 3.

TABLE 3.—*Results of comparative tests with absorbers No. 4 and No. 5.*

[Tests performed Mar. 3, 1916, with "low field" gas.]

Item.	Tower absorber (No. 5).				Baffle plate absorber (No. 4).			
	8 a. m.	9 a. m.	10 a. m.	11 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.
Pressure at inlet to absorber, pounds per square inch.	222	215	211	211	225	220	216	215
Pressure on still, pounds per square inch	3	3	2.75	2.75	3	3	2.75	2.75
Temperatures, ° F.:								
Oil	58	64	66	68	66	66	66	68
Oil outlet from still	207	210	208	209	212	212	212	210
Vapor outlet from cooler	142	170	164	176	170	172	184	172
Cooling water	52	52	54	52	52	52	52	52
Still	218	216	216	216	216	216	216	215
Oil outlet from absorber	54	58	60	62	60	58	60	68
Specific gravity of oil, ° B.:								
Oil at inlet to absorber	34.2	33.7	33.5	34.4	34.5	34.5	34.5	34.4
Oil at outlet from absorber	36.4	36.2	36.0	35.8	35.0	35.2	35.0	34.4
Yield of gasoline, c. c	.....	17,000	16,000	16,310	.....	9,200	9,600	11,300
Specific gravity of absorption gasoline, ° B	.....	85.2	85.5	85.8	.....	80.3	80.3	82.3
Specific gravity of refrigerator gasoline, ° B[a]	.....	91.1	91.8	90.5	.....	90.3	92.0	90.6
Volume of refrigerator gasoline, c. c	.....	1,860	2,200	2,030	.....	2,335	2,130	1,810
Amount of gas passed, cubic feet	.....	.....	73,800	.....	.....	.....	.....	.....
Yield of gasoline, pints per 1,000 cubic feet	.....	.....	1.57	.....	.....	.....	1.18	.....
Rate of flow of gas, cubic feet per hour	24,600				21,600			
Gallons of oil circulated per 1,000 cubic feet of gas	7.9				8.7			

[a] Gasoline condensed from vapors that escaped from still.

EFFECT OF PRESSURE ON THE ABSORPTION OF GASOLINE FROM NATURAL GAS.

Table 4 shows the results of experiments made with the small absorber shown in figure 2, with "mineral seal oil" and "low field" gas, which show the variation in yield of gasoline with different pressures. Atmospheric pressure and pressures of 20, 40, 85, and 110 pounds per square inch were used. It will be noted that the yields vary from 0.71 pint to 1.19 pints of gasoline per 1,000 cubic feet of gas as the pressure was increased from atmospheric to 110 pounds per square inch. The maximum yield is undoubtedly obtained at 110 pounds, for, as shown in Table 1 (pp. 21–22), the yield at 235 pounds per square inch was not appreciably larger.

TABLE 4.—*Results of maintaining a constant feed with varying pressure.*

[Tests were made on "low field gas" with "mineral seal oil" as the absorbent.]

ITEM.	Test 1.			Test 2.			Test 3.			Test 4.			Test 5.		
Date and time of making test	Jan. 26, 1916, 2.48 to 3.58 p. m.			Jan. 29, 1916, 2.25 to 3.40 p. m.			Jan. 30, 1916, 9.35 to 10.45 a. m.			Jan. 30, 1916, 1.05 to 2.25 p. m.			Jan. 31, 1916, 8.15 to 9.37 a. m.		
Number of absorber used	3	4	5	3	4	5	3	4	5	3	4	5	3	4	5
Specific gravity of oil, ° B.	34.2	34.2	34.2	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	34.2	34.2	34.2
Amount of oil used, c. c	1,750	1,500	1,500	1,750	1,500	1,500	1,750	1,500	1,500	1,750	1,500	1,500	1,750	1,500	1,500
Pressure on absorber, pounds per square inch, gage	(a)	(a)	(a)	20	20	20	40	40	40	85	85	85	110	110	110
Gas rate by meter, cubic feet per hour	79						85			75					
Flow of oil, c. c. per 1,000 cubic feet of gas	17,500	15,000	15,000	17,500	15,000	15,000	17,500	15,000	15,000	17,500	15,000	15,000	17,500,	15,000	15,000
Gas consumed, cubic feet	100	100	100	100	100	100	100	100	100	102	102	102	100	100	100
Amount of liquid recovered, c. c	1,770	1,505	1,510	1,845	1,515	1,520	1,825	1,555	1,535	1,850	1,550	1,545	1,875	1,575	1,550
Specific gravity of liquid recovered, ° B	35.1	34.5	34.4	35	35.2	34.7	35.7	35	34.8	35.4	35.2	35.2	36.7	35.5	35.5
Temperature of liquid recovered, °F	68	67	66	66	68	69	64	68	69	68	70	70	64	66	66
Absorption of gasoline in liquid recovered, per cent	1.2	.6	.3	2.3	1.2	.5	2.6	1.0	.....	2.8	1.02	.8	.....	.....	.....
Increase in volume of liquid recovered, c. c	20	5	10	95	15	20	75	55	35	100	50	45	125	75	50
Increase in volume of liquid recovered, per cent	1.1	.3	.7	5.4	1.0	1.3	4.3	3.7	2.3	5.14	3.3	3	7.15	5.0	3.3
Sample for distillation test, c. c	590	502	503	615	505	506	608	518	512	617	516	515	.....	.....	.....
Temperature of condenser bath, ° F	48	48	.....	46	.....	.....	46	.....	(b)	52	52	52	48	48	48
Volume of distillate from sample, c. c	7.0	3.0	1.5	14.0	5.8	2.7	15.6	5.2	.....	20.8	5.2	4.0	21.1	1.0	.3
Temperature range of distillate, ° F	166–260	199–260	.....	160–260	138–260	.....	130–260	.....	.....	120–260	130–260	.....	.....	.....	.....
Volume of gasoline from sample, c. c	21.0	9.0	4.5	42.0	17.4	8.1	46.8	15.6	.....	62.4	15.6	12.0	63.3	3.0	1.2
Yield of gasoline, pints per 1,000 cubic feet of gas	.44	.19	.08	.888	.368	.171	.989	.23	.....	1.31	.33	.25	1.34	.6	.025
Total yield of gasoline, pints per 1,000 cubic feet of gas	0.71			1.427			c1.489			1.89			1.97		

a Atmospheric pressure.

b Sample lost.

c Estimated loss 0.17 pint (see previous test).

OPERATION OF ABSORPTION GASOLINE PLANTS AT LOW PRESSURES.

Any gas, when brought into intimate contact with a liquid by mixing, is absorbed to some extent by the liquid, the amount absorbed varying greatly with the nature of the gas and also with that of the liquid. When gas is mixed with liquid under pressure, the greater the pressure to which the gas is subjected the larger is the amount (by weight) that is dissolved. A simple relation between the solubility of a gas and the pressure applied was discovered by Henry and has come to be known as Henry's law—namely, the amount of gas dissolved by a liquid is proportional to the pressure to which the gas is subjected. Henry tested several gases at pressures ranging from 1 to 3 atmospheres and found that the relation held quite closely. Exceptions to it, however, are not wanting. If the gas is very soluble in the liquid, the law does not hold.

The data given in Table 4 shows that under practically identical methods of operation the yield of gasoline increased with the pressure and that the maximum yield was obtained at 110 pounds pressure. In these tests the absorption of gasoline was less than 3 per cent, but the authors have found that this may be increased to 4 per cent, at high pressure, and the maximum yield obtained. The absorption percentage is calculated as follows:

$$\frac{\text{Volume of gasoline}}{\text{Volume of oil}} \times 100 = \text{absorption percentage.}$$

However, good results can be obtained at low pressures if the quantity of oil in circulation is increased. The authors obtained some experimental evidence on this point by keeping the pressure at atmospheric pressure and varying the oil circulation to determine what degree of saturation of the oil with gasoline is necessary for obtaining the maximum yield of gasoline at low pressures. The results of these tests are shown by the curve in figure 14. The abscissas show the yields in percentages of the total gasoline content, and the ordinates the absorption percentage. With an absorption of 3 per cent only about 10 per cent of the total gasoline content was obtained, whereas with 0.20 per cent absorption 80 per cent of the gasoline was obtained.

Hence if there were required 4 gallons of oil per 1,000 cubic feet of natural gas at 110 pounds pressure and 3 per cent saturation, there would be required $\frac{3}{0.20} \times 4 = 60$ gallons of oil per 1,000 cubic feet of gas at atmospheric pressure to obtain 80 per cent of the maximum yield.

It is well to bring out here that high pressures are not essential. Of course, a great deal of natural gas exists at high pressures, and hence can not be treated at low pressures; but, on the other hand, a great deal of gas can be treated at low pressures. This includes

so-called "dry" natural gas, used for domestic and factory purposes, and billions of feet per year of casing-head gas that is of too low grade to treat by compression methods. To the authors' knowledge no existing patent covers the basic process of treating natural gas at pressures of less than 30 pounds per square inch above atmospheric pressure.

At 25 pounds per square inch the amount of oil in circulation has to be increased 5 to 7 times the amount at high pressure to obtain the maximum amount of gasoline. However, operation of a plant at low pressure is more expensive, and such a plant costs more to build.

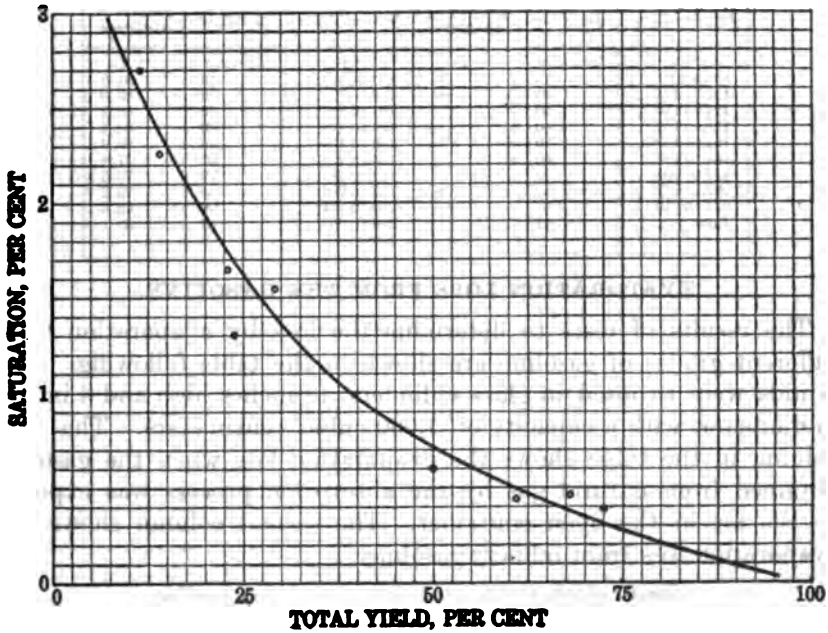

FIGURE 14.—Curve showing relation between the yield of gasoline and the percentage of absorption in oil, at atmospheric pressure.

AMOUNT OF OIL TO USE TO OBTAIN MAXIMUM YIELD OF GASOLINE.

A large number of tests were made with the different absorbers to determine the proper amount of oil to be used per 1,000 cubic feet of natural gas at high pressure in order to obtain the highest yield of gasoline. It was found that the best results were obtained with absorbers No. 4 and No. 6 (see figs. 4 and 6) when about 7 gallons of oil was circulated per 1,000 cubic feet of gas. With the tower absorber No. 5, shown in figure 5, good results could be obtained by circulating 4 gallons of oil per 1,000 cubic feet of gas. Instead of decreasing the amount of oil in this absorber, the practice of the authors was to keep the oil rate at about 7 gallons and increase the gas rate. The best results were obtained by passing about 28,000 cubic feet of gas per hour and circulating about 5 to 6 gallons of oil.

DISTILLATION TEST OF THE GASOLINE.

The gasoline obtained by absorption in "mineral seal oil" and steam distillation rather consistently had a specific gravity of about 80° B. The results of two of many distillation tests that the authors made of such gasoline are shown in the table following. The gasoline was from tests with the large-scale experimental plant shown in figure 3.

Results of distillation tests of gasoline obtained by absorption with "mineral seal oil" from experimental plant.

Gasoline obtained Dec. 22, 1915; specific gravity, 77.4° B.			Gasoline obtained Dec. 29, 1915; specific gravity, 80° B.		
Distillation temperature.	Volume of distillate.	Specific gravity of distillate.	Distillation temperature.	Volume of distillate.	Specific gravity of distillate.
° F.	Per cent.	° B.	° F.	Per cent.	° B.
80 to 102	10	88	80 to 110	10	91.8
102 to 124	20		110 to 124	20	89.0
124 to 138	30		124 to 136	30	86.7
138 to 152	40	78	136 to 146	40	83.4
152 to 168	50		146 to 158	50	80.4
168 to 182	60	72	158 to 172	60	77.4
182 to 202	70		172 to 188	70	73.3
202 to 232	80	68	188 to 208	80	70.2
232 to 250	88	65	208 to 244	90	65.0
Loss	12		244 to 290	98	63.1
			Loss	7	

EVAPORATION LOSS FROM THE GASOLINE.

The results of tests to determine the loss by evaporation from different grades of gasoline are shown in the table following. The liquids were exposed in glass cylinders, 12 inches high and 4 inches in diameter, with a capacity of 1,000 cubic centimeters. The first column in the table shows the evaporation loss when the gasoline obtained from natural gas by the absorption process was exposed to the air in the open container. The second column shows the evaporation loss from refinery gasoline.

Results of tests to determine evaporation loss of gasoline.

	Gasoline from absorption process.	Refinery gasoline.
Specific gravity of gasoline at start, ° B	81.1	60.4
Temperature of gasoline, ° F	56	62
Temperature of room, ° F	70	70
Volume of gasoline at start, c. c	1,000	1,000
Volume of gasoline after 24 hours, c. c	895	976
Volume of gasoline after 48 hours, c. c	840	955
Volume of gasoline after 72 hours, c. c	800	924
Specific gravity of gasoline after 24 hours, ° B	79.6	
Specific gravity of gasoline after 48 hours, ° B	76.5	
Specific gravity of gasoline after 72 hours, ° B	76	58
Temperature of gasoline after 24 hours, ° F	56	
Temperature of gasoline after 72 hours, ° F	61	60
Evaporation loss of gasoline, per cent:		
Loss after 24 hours	10.5	2.4
Loss after 48 hours	16	4.5
Loss after 72 hours	20	7.6

The gasoline obtained from natural gas by the absorption method lost by evaporation 10.5 per cent of its original volume in 24 hours, 16 per cent in 48 hours, and 20 per cent in 72 hours. The refinery gasoline, which is representative of most of that used in automobiles to-day, lost from one-third to one-fourth as much as the natural-gas gasoline.

VAPOR-TENSION TESTS OF THE GASOLINE.

Many vapor-tension tests were made of the gasoline, some of which are shown in the table following. It will be seen that the gasoline does not develop excessive pressure with rise of temperature and that it comes well within the specifications for gasoline that can be shipped in tank cars.

Results of vapor-pressure tests of gasoline obtained by absorption process.

Item.	Test 1.	Test 2.	Test 3.	Test 4.
Date of making test (1915)	Dec. 12	Dec. 16	Dec. 22	Dec. 23
Specific gravity of gasoline ° B	79	78	77.5	81.5
Vapor pressure at 70° F. pounds per square inch	1.25	1.0	.5	1.25
Vapor pressure at 90° F. do	1.50	1.5	1.0	2.0
Vapor pressure at 100° F. do	2.75	2.5	2.5	4.75

The rules of the Interstate Commerce Commission regarding the shipment of natural-gas gasoline follow.

REGULATIONS FOR THE TRANSPORTATION ON RAILROADS OF NATURAL-GAS GASOLINE.[a]

Liquefied petroleum gas is a condensate from the "casing-head gas" of petroleum oil wells, whose vapor tension at 100° F. (38° C.) to 90° F. (32° C.), November 1 to March 1, exceeds 10 pounds per square inch. Liquefied petroleum gas must be shipped in metal drums or barrels which comply with "Shipping Container Specifications No. 5" or in tank cars especially constructed and approved for this service by the Master Car Builders' Association. When the vapor tension at 100° F. (38° C.) exceeds 25 pounds per square inch, cylinders as prescribed for compressed gas must be used.

UNCONDENSED GASOLINE VAPORS IN GAS FROM STILL.

In distilling the gasoline from the "mineral seal oil" by means of steam, an appreciable quantity of uncondensed vapors escaped with the gas. Some of this vapor was liquefied by passing it through a pipe 1 inch in diameter and about 8 feet long placed inside another pipe 2 inches in diameter and 8 feet long. Compressed natural gas which had been used in place of steam to run one of the oil pumps was expanded through the larger pipe to cool and condense as much of the vapors in the inner pipe as possible. A temperature of 0° to 4° F. was obtained. The vapor pressure and other data regarding

[a] From "Regulations of the Interstate Commerce Commission for the transportation of explosives and other dangerous articles by freight and express, and specifications for shipping containers." Published by the Bureau for the Safe Transportation of Explosives and Other Dangerous Articles, in January, 1912.

the condensed vapors obtained in tests of "line L" gas on December 28, 1915, with the plant shown in figures 3, were as follows:

In the test 130,000 cubic feet of natural gas was used, and 450 cubic feet of vapor passed through the condenser. The yield of gasoline obtained from the steam still during this test was 0.94 pint per 1,000 cubic feet of gas; the yield from the vapor passing through condensing pipe was 3¼ gallons per 130,000 cubic feet of natural gas, or 0.2 pint per 1,000 cubic feet, making a total yield of 1.14 pints. This gasoline showed a vapor tension of 0.5 pound at 70° F.; 8½ pounds at 90° F.; and 11 pounds at 100° F. The specific gravity of the gasoline that was caught in the condensing pipe was 94.9° B., and that of the gasoline from the still was 80° B. In large-scale operations the uncondensed vapors are treated in an auxiliary compressor plant for extraction of the gasoline.

EVAPORATION TEST OF GASOLINE CONDENSED FROM VAPORS.

The rate of evaporation of the gasoline condensed from vapors escaping from the still is shown in the table following. The table also shows the rate of evaporation of mixtures of the gasoline with naphtha having a specific gravity of 55° B., and of the naphtha alone.

Evaporation losses from the gasoline and mixtures of gasoline and naphtha.

	Mixture of 500 c. c. of gasoline and 500 c. c. of naphtha.	Mixture of 250 c. c. of gasoline and 750 c. c. of naphtha.	Gasoline.
Volume of sample, c. c.	1,000	1,000	1,000
Temperature of room, ° F.	58	58	58
Specific gravity, ° B	71.6	63.4	80.0
Volume after 6 hours	975	988	963
Volume after 18 hours	943	982	912
Volume after 24 hours	922	968	870
Volume after 30 hours	902	954	840
Volume after 42 hours	882	942	812
Volume after 48 hours	880	943	805
Volume after 72 hours	854	928	740
Specific gravity at end of 72 hours, ° B.	848	928	755
Percentage loss after 18 hours	5.2	3.2	12.0
Percentage loss after 48 hours	12	5.2	19.5
Percentage loss after 72 hours	14.6	7.2	24.5

COST OF AN ABSORPTION PLANT.

As a result of the experiments described, which were on a fairly small scale, work was started on a large plant capable of handling 60 million cubic feet of natural gas daily. Exact figures for the costs of installing such a plant can not be given. It is believed, however, that a conservative estimate, figured on plant capacity, is $1.50 to $2 per 1,000 cubic feet of gas handled per day for a plant with a daily capacity of 60 to 90 million cubic feet or more, to $2 to $4 for a plant with a daily capacity of 30 million cubic feet or less.

The returns are large. At a cost of $1.50 per 1,000 cubic feet of plant capacity, a plant to handle 60 million cubic feet per day would cost $90,000. If only 1 pint of gasoline were extracted from each 1,000 cubic feet of gas the yield per day from 60 million cubic feet would be 7,500 gallons. The gross income at 20 cents per gallon for gasoline would be $1,500 per day.

CONSTRUCTION OF LARGE-SCALE ABSORPTION PLANT.

As a result of the experimental work with the plant shown in figures 7 to 13 a large plant, having a capacity of approximately 60,000,000 cubic feet of natural gas per day, was constructed. This plant is operating successfully and producing 1.2 pints of gasoline per 1,000 cubic feet of gas. The gas used in this plant is treated at a pressure of about 235 pounds per square inch.

Ten absorbers of the vertical type are used in parallel; each one is 30 feet high and 30 inches in diameter. Hollow tile is used as filling to distribute the oil as it falls through the absorber and comes in contact with the gas. Fourteen vertical heat exchangers are connected in series with piping so arranged that any one of them can be cut out of service. Each exchanger consists of an 18-inch pipe, 18 feet long, containing thirty-one 2-inch tubes. The cold oil passes through the 2-inch tubes, and the hot oil, traveling in the other direction, passes around the tubes, thereby providing for an exchange of heat between the hot and the cold oil. The still consists of a sheet-iron boiler shell 8 feet in diameter and 26 feet long, with a stone tower 26 feet high. Six pipe connections arranged in T form introduce live steam into the still.

A view of the absorbers is shown in Plate I, *B;* the stills, condensers, and heat exchangers are shown in Plate I, *A*. A general view of the plant is shown in Plate II, *A*.

At a plant other than the one described above the absorbers consist of 20-inch pipe, 20 feet high, with a flange tapped for 8-inch pipe at the top and a 20-inch by 6-inch swedge at the bottom, welded on. One foot above the welded joint of the swedge nipple an 8-inch collar is welded to the side of tower for a gas inlet. The gas outlet is through the 8-inch opening in the flange at the top of the tower. Two feet below this flange six openings are tapped in a ring around the 20-inch tower and in these openings are screwed spray nozzles pointing downward, their center lines forming an angle about of 30° with the center line of the tower. These nozzles have $\frac{3}{16}$-inch openings behind which are inserted twist drills. The fresh oil is pumped through the nozzles at a pressure 100 pounds higher than the gas pressure, resulting in a fine spray or fog of fresh oil being directed downward against the upward stream of gas through the tower.

The tower is filled from a point 1 foot above the gas-inlet opening to a point 9 feet above it with wooden slats ½ inch by 6 inches in dimension, standing on edge, with the lengths of alternate layers at right angles to each other. The oil spray strikes these slats and trickles down over their surfaces in thin layers, thus offering a large surface contact with the upward stream of gas through them. The oil flows out through the swedge nipple at the bottom into a receiving tank, from which it is forced by the gas pressure of the system to the oil heat interchangers, and thence to the still.

Each tower as above described is designed for a capacity of 3,000,000 cubic feet of gas per day at 300 pounds gage pressure. The rate of oil feed is four gallons per 1,000 cubic feet. The idea sought to be embodied is the principle of countercurrent flow combined with intimate mixing by atomizing the oil and having fresh oil mingle with the gas at the last moment of contact between the two, when the gas is lean.

HEAT EXCHANGERS.

The heat exchangers for warming the cold oil from the absorbers with the hot oil discharged from the still are made up in units, each of which consists of a rectangular sheet-iron box, with welded corner joints and flanged cover. Each box is 7½ inches wide, 40 inches high, and 20 feet long inside, and contains 16 pressed-steel, two-column, four-section, 38-inch, hot-water radiators fitting snugly between the walls of the box. The opposite ends of the alternate sections of the radiators have baffle plates extending to the top and bottom walls of the box, thus causing the hot oil from the still to flow back and forth through the spaces between the individual radiator sections in series from one end of the box to the other. This gives the oil a long path, at comparatively high velocity, favorable to a rapid interchange of heat. The cold oil from the absorbers flows through the inside of the radiators in the opposite direction, thus further increasing the efficiency of the heat exchange. The box itself is lagged with wood on the outside to reduce radiation losses. Two of these boxes in series are designed to have a capacity corresponding to 6,000,000 cubic feet of gas per day, or an oil flow of 17 gallons per minute.

STILL.

Two types of still are being installed, both of which are based on the same principle—to cause the incoming charged oil to be spread in thin layers over the hot evaporating surfaces. In one type the still tank is 48 inches in diameter and 12 feet high, with banks of pressed-steel radiators set in it one over the other; at the top a sheet-iron distributing box receives the charged oil and causes it to flow

A. STILLS, CONDENSER, AND HEAT EXCHANGER.

B. ABSORBER AT LARGE GASOLINE PLANT.

A. GENERAL VIEW OF LARGE GASOLINE PLANT.

B. HORIZONTAL ABSORBERS IN LARGE GASOLINE PLANT.

over the top bank of radiators, and thence down to the next, and so on until it reaches the bottom, from where it is discharged to the heat exchangers. The radiators are heated by live steam, and, as the oil passes over their hot surfaces, the gasoline is evaporated from the oil.

The other type of still consists of an old 5 by 12 foot boiler shell with the flues removed and one head replaced by a flanged head. This shell lies horizontally and within it are three sheet-iron troughs, one over the other, containing 1-inch steam coils. The troughs are shallow and inclined so that the oil coming in at one end of the top trough flows over the hot coils and at the other end overflows into the trough below it, and so on until it reaches the bottom of the still, having been freed of its gasoline. Provision is made for injecting live steam into the still when necessary.

CONDENSER.

A Young atmospheric condenser is used for condensing the gasoline vapor. This consists of vertical cast-iron headers, containing separating baffles, with 2-inch pipe connecting the header towers in such manner that the vapor enters the bottom of one tower, encounters a baffle for separating the first condensate, then passes through two parallel lengths of 2-inch pipe to the next header and baffle, where condensate is further removed, then back through two more pipes to another separating header, and so on until three passes have been made, when all the vapor becomes condensed. The pipes are cooled by water dripping over them from an overhead trough, and also by the cold air in wintertime. The countercurrent flow, with continuous separation, makes it possible to segregate the first oily condensate from the later clear gasolines. A cooler of this type to condense 2,000 gallons of gasoline per day with cooling-water temperature of 50° F. consists of three passes of doubled 2-inch pipe 20 feet long, with the necessary separating headers at each end.

OIL SEPARATORS.

In order to separate the absorbing oil from the gas, horizontal pipe separators are used, consisting of 16-inch pipe with 6-inch collars welded in the lower side and spaced 6 feet apart. At these openings baffle plates are welded into the pipe on the downstream side of the opening, and extend across one-half the diameter of the pipe. On the upstream side baffle plates are welded in, obstructing the top half of the pipe cross section. These top plates deflect the incoming gas and oil mixture toward the drip openings and the force of the impact causes a separation of the oil from the gas. In order to assist separation the top baffles are cut with a 120-degree segment opening, the lower edges of which are turned over against the direction of flow to serve as troughs for carrying the separated oil out of the stream of

gas to the sides of the pipe and thence to the drip openings. Four such drip openings are designed to separate all the oil from the gas, and a 16-inch separator is connected into an 8-inch line through welded swedge nipples.

CONSTRUCTION OF ABSORPTION PLANT NEAR CATLETTSBURG, KY.

An absorption plant was constructed near Catlettsburg, Ky., that has a capacity of 80,000,000 cubic feet of gas per day.

The company has installed one 12-foot by 30-foot still with a 5-foot stone tower 35 feet high. The condenser box is 16 feet wide, 25 feet long, and 10 feet high. The auxiliary condenser is of the vertical tube type. The oil circulation is 4 gallons of oil per 1,000 cubic feet of gas treated and the amount of gasoline obtained is 140 gallons per 1,000,000 cubic feet of gas. The temperature in the still is maintained at 216° F. Six heat exchangers are used, each containing 357 iron tubes 1 inch in diameter and 7 feet 10 inches long. There are 10 absorbers, of the horizontal type, each 5 by 20 feet. The oil cooler consists of six rows of 2-inch pipe, each row eight pipes high and 18 feet long. Steam is generated at 125 pounds pressure from 300 boiler horsepower. The vapors from the storage tanks and the noncondensable vapors from the still are compressed in a two-stage compressor with 10 by 12 inch and 4¼ by 12 inch cylinders. The compressed gas is cooled by passing it through two rows of 2-inch pipe, each row being eight pipes high and 18 feet long.

At the time one of the authors of this report visited the plant trouble was experienced on account of the high temperature of the oil, water, and gas. Also the gas compressor was not large enough to handle all of the vapors.

Plate II, *B*, shows the arrangement of horizontal absorbers at a plant in Oklahoma.

CALCULATED STEAM AND WATER REQUIREMENTS FOR AN ABSORPTION PLANT.

The amount of steam and water required for absorption-process gasoline plants of various sizes has been calculated from data accumulated by the authors in operating the plant shown in figure 3. These requirements are based on the fact that steam exhausts from various pumps and compressors around the plant into a low-pressure steam line and then into the steam stills, also that the overflow water from the condensers (at a temperature of 80° F.) is more than enough for the auxiliary condenser or cooler, so that the amount of condensing water required is computed for the main condensers only. The amount of water required for cooling the compressed gas from the

weathering tank and condensers is very small and varies considerably in different plants, but for natural gas that contains about 1½ pints of gasoline per 1,000 cubic feet is about 0.03 gallon of water per 1,000 cubic feet.

STEAM REQUIREMENTS.

In distilling gasoline from the oil heat is required for two purposes: First, to raise the temperature of the oil and gasoline to the vaporization point of the gasoline; and second, to supply heat absorbed by actual vaporization. Hence a knowledge of the specific heat of the oil and gasoline and of the latent heat of the gasoline is necessary.

The number of British thermal units required to raise the temperature of 1 pound of a substance 1° F. is called the specific heat of the substance.

The heat absorbed without change of temperature during a change of state, as from a solid to a liquid or from a liquid to a gas, is called the latent heat.

These constants have not been determined precisely for different grades of gasoline or oil, but are approximately as follows:

Latent and specific heats of petroleum products.[a]

Product.	Specific heat.	Temperature.	Latent heat.
	B. t. u.	*° F.*	*B. t. u*
Kerosene, gravity 43° B	0.499	(b)	105.4
Naphtha, gravity 56° B	.0510	175° F.	103.5
Gasoline, gravity 65° B	.569	b 115° F.	100.6
Gasoline, gravity 89° B	.580	b 70° F.	100.2

[a] Redwood, Beverton, Petroleum, 1913, vol. 1, pp. 219–221. [b] Initial boiling point.

In view of the fact that the exact constants for "mineral seal oil" and gasoline can not be given, the best that can be done is to use for "mineral seal oil" the constants as given in the above table for kerosene, and use for absorption-process gasoline the constants given for 89° B. gasoline. With this and other data the heat required in the stills can be calculated as follows:

Temperature of oil entering still, 135° F.
Temperature of vapors from still, 210° F.
Temperature change, 75° F.
Specific heat of "mineral seal oil," 0.50.
Weight of "mineral seal oil," 7 pounds per gallon.
Heat required to raise 1 gallon of "mineral seal oil" from 135° F. to 210° F.=75×.50×7=262.5 B. t. u. per gallon.
Specific heat of gasoline, 0.58.
Latent heat of gasoline, 100 B. t. u. per pound.
Weight of gasoline, 5.5 pounds per gallon.

Heat required to raise temperature of gasoline from 135° F. to 210° F.=75×0.58×5.5=239.5 B. t. u. per gallon.

Heat required to vaporize gasoline=100×5.5=550 B. t. u. per gallon.

Hence the total heat required to vaporize gasoline=550+239.5=789.5 B. t. u. per gallon.

The authors' experiments have shown that the proper rate of circulation of oil through an absorption plant at high pressures is one where the mixture of oil and gasoline does not contain over 4 per cent by volume of gasoline.

Then for each volume of "mineral seal oil" the heat required to vaporize the contained gasoline is $0.04 \times 789.5 = 31.58$ B. t. u., and the total heat required for each gallon of "mineral seal oil" in circulation with its contained gasoline is $262.5 + 31.58 = 294.08$ B. t. u.

Some of the steam entering the still is not condensed in the still but passes through to the auxiliary condenser without doing any useful work. To cover this loss and radiation losses the assumption can be made that the still has an efficiency of 80 per cent. Then the amount of heat required to be delivered to the still for each gallon of "mineral seal oil" circulated will be $294.05 \div 0.80 = 367.5$ B. t. u.

In practice, the steam used is largely exhaust steam from pumps about the plant and enters the still at a pressure of about 3 pounds per square inch. Saturated steam at this pressure corresponds to a temperature of 219.4° F., and the thermal energy imparted to and contained in the steam in raising it to this temperature from 32° F. is 1,153.1 B. t. u. per pound. Condensed water leaving the still at about 210° F. has a heat content above 32° F. of 178 B. t. u. per pound. The difference is 975.1 B. t. u. per pound. Hence there will be required $\frac{367.5}{975.1} = 0.377$ pound of this exhaust steam for each gallon of oil circulated.

As stated above, this exhaust steam entering the still is largely exhaust steam from pumps about the plant. It is generated at a pressure of about 125 pounds per square inch to run the pumps. The boiler feed water available is the condensed water from the stills and the overflow from the auxiliary condensers. A feed-water temperature of about 200° F. may be depended upon. The heat content of saturated steam at 125 pounds pressure is 1,192.2 B. t. u. per pound, and that of water at 200° F. is 168 B. t. u. per pound. Therefore the available heat is $1,192.2 - 168 = 1,024.2$ B. t. u. per pound of steam.

One boiler horsepower is equivalent to 33,479 B. t. u., hence $\frac{1,024.2}{33,479} = 0.0306$ boiler horsepower is required per pound of steam. It follows that for each gallon of "mineral seal oil" circulated, $0.377 \times 0.0306 = 0.01154$ boiler horsepower will be required per 1,000 feet of gas treated per hour.

WATER REQUIREMENTS FOR ABSORPTION PLANT.

The gasoline vapor leaving the auxiliary condensers has a temperature of 180° F. If this vapor is cooled to 60° F., and the specific heat of the gasoline is 0.58 and the weight of 1 gallon is 5.5 pounds, the heat given up in cooling is $(180-60)\times 0.58\times 5.5=382.8$ B. t. u. per gallon. If the latent heat of gasoline is 100 B. t. u., the amount of heat given up in condensing 1 gallon is $100\times 5.5=550$ B. t. u. The temperature of the water in the condenser ranges from 60° to 80° F., hence the amount of heat absorbed by the water is $20\times 8.33=166.6$ B. t. u. per gallon of condensing water. Therefore the amount of water required for each gallon of gasoline condensed is $\frac{382.8+550}{166.6}=5.6$ gallons. This water overflows from the condenser box into the auxiliary cooler and is more than enough for the latter.

WATER FOR OIL-COOLING COILS.

The oil comes from the heat exchanger at a temperature of approximately 135° F. and is cooled to at least 70° F. before it reenters the absorber. The specific heat of "mineral seal oil" is 0.50 and its weight is 7 pounds per gallon. Hence the amount of heat to be extracted is $(135-70)\times 7\times 0.50=227.5$ B. t. u. The temperature of the water before flowing over the cooling coils is 60° F. and after cooling is 100° F., therefore the amount of heat absorbed per gallon of cooling water is $(100-60)\times 8.333=333$ B. t. u. per gallon, and for cooling purposes $\frac{227.5}{333}$ or 0.705 gallon of water is required per gallon of "mineral seal oil" circulated.

The table following shows the steam and water requirements for absorption plants treating natural gas containing varying amounts of gasoline.

Suppose that the steam and water requirements are wanted for a high-pressure absorption plant to treat 60,000,000 cubic feet of natural gas containing 1½ pints (or 0.1875 gallon) of gasoline per 1,000 cubic feet of gas. The oil rate to use is 4.69 gallons per 1,000 cubic feet of gas treated, and the boiler horsepower required to treat 60,000,000 cubic feet per day, or 2,500,000 cubic feet per hour, is $2,500\times 0.054=135$ boiler horsepower. The quantity of water for the plant is $4.35\times 60,000=261,000$ gallons per 24 hours.

It is best to increase the calculated values as given by the authors by 20 per cent, and to install double this boiler capacity to permit cleaning the boilers without shutting down the plant.

Quantities of steam and water required per 1,000 cubic feet of gas treated by absorption plant at high pressures.

Steam for distillation.			Water supply.[a]			
Yield of gasoline.	Oil circulated.	Boiler horsepower-hours.	Condensers.	Oil cooler.	Gas cooler.	Total.
Gallons.	*Gallons.*		*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
0.0625	1.56	0.018	0.35	1.1	0.01	1.46
.125	3.10	.036	.7	2.2	.02	2.92
.1875	4.69	.054	1.05	3.3	.03	4.35
.250	6.25	.072	1.4	4.4	.04	5.84
.375	9.40	.109	2.1	6.6	.06	8.76
.50	12.5	.144	2.8	8.8	.08	11.68
.625	15.6	.180	3.5	11.0	.10	14.6
.75	18.75	.216	4.2	13.2	.12	17.52
1.00	25.00	.2885	5.6	17.6	.16	23.36
1.50	37.50	.433	8.4	26.4	.24	35.04
1.75	43.75	.505	9.8	30.8	.28	40.88
2.00	50.0	.577	11.2	35.2	.32	46.72
3.00	75.0	.865	16.8	52.8	.48	70.08
4.00	100.0	1.154	22.4	70.4	.64	93.44
5.00	125.0	1.443	28.0	88.0	.80	116.8

[a] Includes water for cooling compressed gases from weathering tank and still.

APPLICATION OF THE ABSORPTION PROCESS TO CASING-HEAD GAS.

An interesting possibility lies in the application of the absorption process to casing-head natural gas that is at present being treated or can be treated by compression-and-condensation methods. To gain information on this point the authors made some tests with a small absorption plant of casing-head gas at a compression and condensation plant near Charleston, W. Va. In this compressor plant the natural gas is withdrawn from the oil wells under a pressure of about 17 inches of mercury, absolute (about 8.3 pounds per square inch), and is delivered at about atmospheric pressure to a compressor, where it is compressed at a pressure of about 30 pounds per square inch. The gas is cooled, the condensate removed, and is then compressed in the high-stage compressor at a pressure of about 180 pounds per square inch. Next the gas is passed through water-cooled tanks to the accumulator tanks, where the condensate is drawn off. The residual gas, which leaves the high-stage accumulator, at a pressure of about 110 pounds per square inch, is sold to a natural gas company.

DATA ON COMPRESSION PLANT PRACTICE.

Data obtained by the authors for a 24-hour run on the compression plant follows:

Data on compression plant near Charleston, W. Va.

Amount of natural gas used	cubic feet..	378,000
High-pressure accumulator tank:		
Pressure in tank	pounds per square inch..	180
Yield of gasoline	gallons..	1,714
Gravity of gasoline	° B..	92
Vapor tension of gasoline at 100° F	pounds per square inch..	23
Low-pressure accumulator tank:		
Pressure in tank	do....	30
Yield of gasoline	gallons..	170
Gravity of gasoline	° B...	750
Vapor pressure of gasoline at 100° F	pounds per square inch..	8¼
Total yield from accumulator tanks	gallons..	1,884
Gasoline in stock tanks after reduction of pressure and after weathering:		
Yield	gallons..	934
Specific gravity	° B..	87.4
Vapor tension at 100° F	pounds per square inch..	13
Yield in accumulator tanks per 1,000 cubic feet of gas	gallons..	4.98
Yield after "weathering" in stock tanks per 1,000 cubic feet of gas	do....	2.47

The last figure, 2.47 gallons of gasoline per 1,000 cubic feet of gas, represents the quantity of gasoline actually sold from the compressor plant. In other words, there was a weathering loss of 1,884 − 934 = 950 gallons, or 50.4 per cent.

Tests of the weathered gasoline from the stock tanks showed that further "weathering" to reduce the vapor pressure to 9 pounds per square inch resulted in an additional loss of 15 per cent in volume and reduced the gravity to 86.7° B. Therefore the production of gasoline having a vapor pressure of 9 pounds per square inch was 2.1 gallons of gasoline per 1,000 cubic feet of natural gas treated in the plant, and the entire "weathering" loss to produce gasoline of 9 pounds vapor pressure was 57.9 per cent.

TESTS BY ABSORPTION PROCESS.

The first tests the authors conducted on casing-head natural gas, using the absorption process, were with a small absorber somewhat similar to that shown in figure 2 (p. 19), except that it was surrounded with four coils instead of one coil, and the gas passed through each of these coils successively. Also the absorber was of larger capacity, holding about 4,000 c. c. of oil, whereas the one illustrated in figure 2 held about 1,700 c. c. This reconstruction was necessary because casing-head natural gas is much richer in gasoline than the "dry" natural gas with which the absorber shown in figure 2 was used, hence more absorbing oil had to be used and longer contact provided between the oil and gas.

In some of the tests with the small absorber, the gas was used after it had passed through the low-stage compressor of the compression plant and before it had been cooled and gasoline condensed

out of it. Other tests were made of residual gas from the compression plant to determine if more gasoline could be extracted from the gas after the compression plant had operated on it. Table 5 following shows the results of these tests.

Test 1 was made of fresh casing-head natural gas at the plant near Charleston, W. Va., where the tests described on page 52 were conducted. Test 2 was made of residual gas from the same plant after gasoline had been extracted from it by the compression method. Tests 3 and 4, which were conducted in the same manner as tests 1 and 2, were made at another compression plant situated near Charleston, W. Va.

TABLE 5.—*Results of tests of casing-head gas with small absorber.*

Source of gas	Compression plant No. 1.		Compression plant No. 2.	
	Fresh gas.	Residual gas.	Fresh gas.	Residual gas.
Test No.	1	2	3	4
Specific gravity of "mineral seal oil" used, ° B	36	36	36	36
Volume of oil used, c. c	4,100	4,100	4,100	4,100
Gas pressure on absorber, pounds per square inch	32	122	25	123
Gas consumed, cubic feet	25	80	25	80
Liquid recovered:				
Volume, c. c	4,775	4,325	4,685	4,450
Gravity, ° B	39.5	39.0	39.5	37.0
Temperature, ° F	70	68	77	77
Absorption percentage	4.8	0.5	4.9	1.3
Increase, c. c	675	225	585	250
Volume increase, per cent	16.5	5.5	12.0	6.1
Sample for distillation, c. c	551	541	464	556
Temperature of condenser, ° F	50	50	50	50
Distillate, c. c	25.5	2.8	23.0	7.0
Gasoline extracted during test, c. c	229.5	22.4	230	56
Gravity of gasoline, ° B	.....	86.0	.....	86.0
Gasoline, gallons per 1,000 cubic feet of gas	2.43	0.07	2.43	0.18

Test 1 showed that 2.43 gallons of gasoline could be extracted by absorption methods from the fresh casing-head gas used at the first plant, under a pressure of 32 pounds per square inch and an oil temperature of 70° F., as compared with 2.47 gallons of salable gasoline extracted by the corupression and condensation method. The residual gas from this compression plant (test 2) yielded only 0.07 gallon of gasoline per 1,000 cubic feet of gas. In other words, the compression plant had extracted practically all of the gasoline from the gas, so nothing was gained by treating the residual gas from the compression plant by the absorption method.

The casing-head gas used at the second plant yields by the compression and condensation method the same amount of gasoline as that used at the first plant. The same amount of gasoline was produced (test 3) from it by the absorption method as from the gas used at the first plant. The yield of gasoline obtained from the residual gas

by the absorption method was slightly larger than that obtained by treating the residual gas from the first plant, being 0.18 gallon per 1,000 cubic feet of gas, or 72 gallons per 400,000 cubic feet of gas treated. It is believed, however, that with more efficient operation of the compression plant even this quantity could not be obtained. In other words, it seemed scarcely worth while to treat residual gas from these two compression and condensation plants by the absorption method. However, at some compression plants the extraction is not nearly so complete.

EXPERIMENTS WITH LARGE-SCALE ABSORPTION PLANT.

Experiments with the casing-head natural gas treated at the first compression plant described above were made with a large-scale absorption plant similar to that shown in figure 3. The natural gas was compressed to a pressure of 20 to 29.2 pounds per square inch in the low-stage compressor and then passed through the absorption plant. In only one case was the gas cooled after leaving the compressor and before entering the absorber. The results of these tests were as follows:

TABLE 6.—*Results of tests of casing-head gas with large-scale absorption plant.*

	Test 1.	Test 2.	Test 3.	Test 4.	Test 5.	Test 6.
Pressure of gas, pounds per square inch...	24	20	22	23	29.2	28
Rate of gas flow, cubic feet per hour.....	5,900	5,100	5,000	5,400	3,300	2,800
Rate of oil flow per 1,000 cubic feet of gas..	23.5	33.6	45.6	38	40.2	59
Yield; gallons per 1,000 cubic feet.....	1.69	1.99	1.91	1.90	[a]1.91	[b]2.24
Specific gravity of gasoline, °B.....	82	83	84	82	80	83

NOTE.—Oil entering tank was warm, owing to the fact that the oil absorbed heat from the gas.
[a] After passing cooler.
[b] Made on rainy day; rain lowered temperature of absorbing oil.

It will be observed that the yield of gasoline increased as the rate of oil flow was increased and the rate of gas flow was diminished, and that the largest yield was obtained with an oil flow of 59 gallons per 1,000 cubic feet of gas treated and a gas flow of 2,800 cubic feet per hour. This yield is not quite as large as that obtained by using the small-scale absorber (see Table 5), but undoubtedly if the gas had been cooled before it entered the absorber, and closer adjustments of oil and gas flow had been made, a larger yield could have been obtained with the large-scale absorption plant.

Experiments were also made with the large-scale absorption plant, using residual gas from compression plant No. 2, for comparison with the results of tests 3 and 4, shown in Table 5, which were made with a small absorber.

The oil circulation in these large-scale tests of residual gas varied between 2 and 16 gallons per 1,000 cubic feet of gas treated. The gravity of the oil after passing through the absorber was 46° B., as

compared to an original gravity of 36° B. The rate of flow of the gas through the absorber was approximately 10,000 cubic feet per hour at a pressure of 110 pounds per square inch. The gasoline recovered had a gravity of 86° B. and was not obtained in commercial quantities. Large volumes of gas were absorbed by the oil that upon distillation could not be condensed at the temperature of the cooling water (64° F.).

These large-scale tests bear out the results obtained with the small absorber, namely, that no additional gasoline could be obtained by treating the residual gas from the compressor plant by the oil absorption process.

EVAPORATION TESTS.

Evaporation or "weathering" tests that were made of the gasoline obtained from the large absorption plant and compression plant No. 1 are shown in Table 7 following:

TABLE 7.—*Comparative evaporation tests of gasoline from compression and absorption plants.*

Source of gasoline.	Absorption plant.	Absorption plant.[a]	Low-pressure accumulator tank of compression plant.	High-pressure accumulator tank of compression plant.	Stock tank.[b]	Stock tank.[b]
Test No.	1	2	3	4	5	6
Size of cylinder tests were made in, c. c.	500	500	500	1,000	1,000	1,000
Duration of test, hours	8	5½	6	2½	6	6
Gravity at beginning of test, °B.	84.4	84	77	Above 92	Above 92	Above 92
Gravity at end of test, °B.	81.8	84	72.8	.....	86	86
Total loss, per cent	15	12	18	44	40	40
Rate of loss per hour, per cent	1.9	2.3	3	17.6	6.7	6.7
Temperature of air, °F.	49	74	46	46	.....	.....

[a] Placed near steam coil to hasten evaporation.
[b] After 45.5 per cent loss in transferring gasoline from accumulator tank to stock tank.

The more stable character of the gasoline produced by the absorption process is brought out by the foregoing evaporation tests. Tests 2 and 3 can be compared with tests 5 and 6, for they show the results of evaporating or "weathering" the final product obtained by both processes. The average rate of loss per hour was over twice as great in the case of the gasoline obtained by the compression method.

VAPOR-PRESSURE TESTS.

Table 8 shows the results of comparative tests of vapor pressures of gasoline obtained by the compression method and by the absorption method.

TABLE 8.—*Results of vapor-pressure tests of gasoline made by absorption and by compression methods.*

Source of gasoline.	Absorption plant.[a]	Compression plant.[b]	Compression plant.[c]	Compression plant.[c]
Test No.	1	2	3	4
Gravity of gasoline, °B.	86.2	87.4	92	75
Vapor pressure at 70° F., pounds per square inch	3½	3¾	17	3¾
Vapor pressure at 90° F., pounds per square inch	7½	9½	20	6
Vapor pressure at 100° F., pounds per square inch	10	13½	23	9

[a] Before weathering.
[b] After weathering and ready for shipment.
[c] Product from high-pressure accumulator tank.

The results of these vapor-pressure tests show a marked difference between the vapor pressure of absorption-process gasoline and that of gasoline made by the compression process. The former did not exert as much pressure before "weathering" as the latter did after weathering. It is well to call attention at this point to the reason for this difference. In a compression plant a certain pressure and temperature will be found by experience to produce the maximum yield of salable gasoline, but in obtaining this gasoline no selective pressures and temperatures can be applied that will produce solely vapors of the kind desired—that is, gasoline just right for shipping and consumption. Instead, some of the butane (gas at ordinary temperatures) is liquified and other paraffin gases, such as propane, ethane, and even methane, are dissolved in the liquid produced. Hence, the condensate evaporates rapidly when exposed to the air, largely because of the escape of the liquified and dissolved gases. These gases also exert high vapor pressures, as shown by the curves in figure 15, plotted from data obtained in experiments by the senior author.

On the other hand, gasoline made by the absorption process undergoes a selective action in the process of distilling the gasoline from the absorbed oil. The temperatures employed in the condenser are not low enough to liquify the evolved gases—butane, propane, ethane, and methane—hence, most of the condensate produced consists of those constituents that are fairly stable at ordinary temperatures.

However, as mentioned on page 43, those uncondensed vapors that escape from the still can be compressed and condensed, yielding gasoline of high vapor pressure and high rate of evaporation.

COMPARISON OF COMPRESSION METHOD AND ABSORPTION METHOD AS THE RESULT OF FOREGOING TESTS.

In summing up the results of these comparative tests of the compression and absorption methods as applied to casing-head gas, it can be stated that approximately as much gasoline can be obtained

by the absorption method at a pressure of about 25 pounds per square inch as by the compression method, and, further, a product of lower vapor pressure and lower rate of evaporation can be obtained. One important point, however, has to be considered, namely, that at many compression plants the residual gas is disposed of by forcing it into natural-gas lines at pressures higher than 25 pounds per square

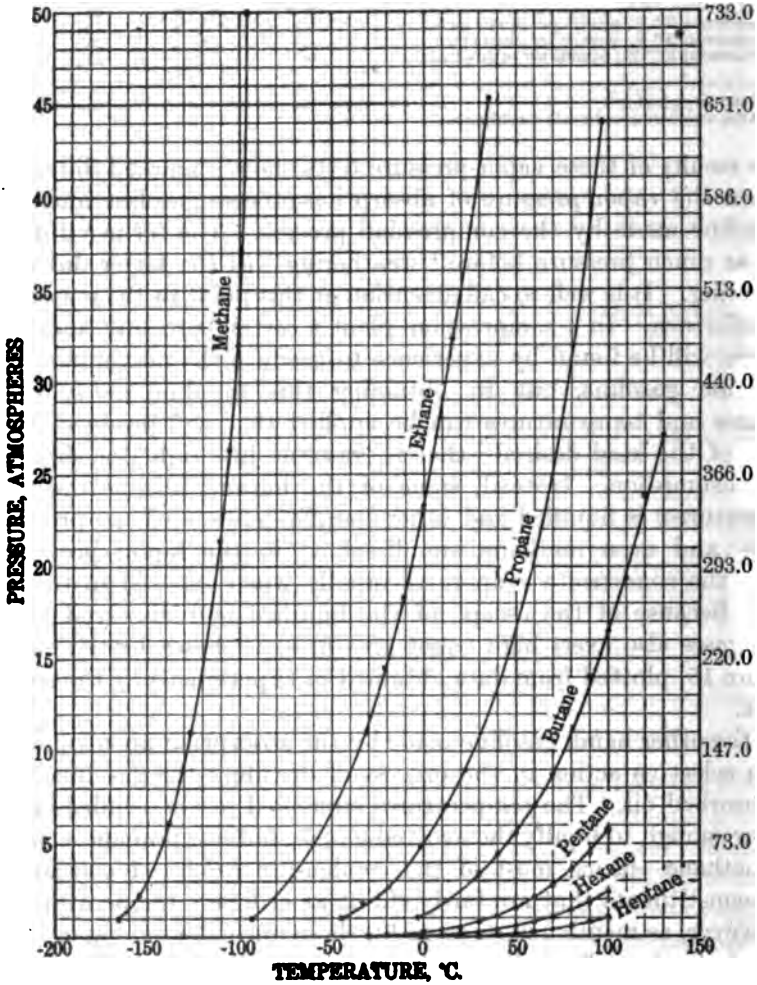

FIGURE 15.—Vapor pressure of paraffin hydrocarbons at various temperatures.

inch, being 110 pounds per square inch in the case of the compression plant herein described. Hence a compressor is needed. As the compressor with a gas engine for driving it is the most expensive part of a compressor plant and is necessary, it would be out of the question to install an absorption plant instead of the compression outfit, if the residual gas has to be pumped into a natural-gas line at high pressures. Moreover, the authors believe that the cost of operating an absorption plant is greater. The great value of the application of the absorption

process to casing-head gas lies in the fact that billions of cubic feet of this gas will be available for treatment that is too lean for treatment by compression and condensation. The significance of this statement lies in the fact that the amount of lean casing-head gas produced is much larger than the amount of rich gas—gas containing 1.5 or more gallons of gasoline per 1,000 cubic feet—that can be treated by compression and condensation.

APPLICATION OF ABSORPTION PROCESS TO GAS FROM OIL WELLS PRODUCING FROM A SAND INTO WHICH AIR HAS BEEN PUMPED UNDER PRESSURE.

A promising field for the absorption process lies in the treatment of gas from oil wells where compressed air has been forced into some of the oil wells on a lease for the purpose of increasing the production of oil from the other wells. The process consists of pumping compressed air into several wells on a lease, thus forcing more oil from that producing stratum into and out of other wells which are pumped than could otherwise be obtained. Old oil wells are treated by this method.

Messrs. Smith & Dunn, of Marietta, Ohio, have successfully installed compressor plants at such wells in southeastern Ohio and northern Pennsylvania. On one property they report an increase from 4½ barrels to 32½ barrels per day; on another, from 22 to 70; and on a third, from 17 to 32.

The air in passing through the oil sand picks up and carries with it some of the lighter constituents of the oil, that is—gasoline.

Of course a certain amount of the natural gas in the strata mixes with and emerges with the air and gasoline. The authors obtained information regarding the amount of gasoline carried by the mixtures as they flowed from different oil wells by collecting several samples and analyzing them. The results of three typical analyses are shown in Table 9 following.

TABLE 9.—*Analyses of mixtures of air and natural gas from oil wells.*

Constituent.	Sample 1.	Sample 2.	Sample 3.
Carbon dioxide (CO_2).....per cent..	0.20	0.70	1.00
Oxygen (O_2).....do....	18.10	15.40	16.20
Natural gas.....do....	7.2	10.6	12.80
Nitrogen (N_2).....do....	74.50	73.30	70.00
Gasoline.....pints per 1,000 cubic feet of gas..	4.6	7.3	5.9

Sample No. 1 represents about 135,000 cubic feet of gas. Sample No. 2 represents about 75,000 cubic feet of gas issuing from 12 wells. Sample No. 3 represents 25,000 cubic feet of gas from 1 well.

It will be observed that the gasoline content ranges from 4 6 to 7.3 pints per 1,000 cubic feet of gas.

ABSORPTION OF GASOLINE WITH NAPHTHA AND PETROLEUM DISTILLATE.

In the tests heretofore described the natural gas was passed through only one kind of absorbing oil and then the absorbed gasoline was separated from the oil by distillation with steam. In tests with "mineral seal oil," made with the small absorber shown in figure 2, the yield from "line L" gas by this process was about 1.2 pints of gasoline per 1,000 cubic feet of gas, and from "low field" gas, about 1.8 to 1.9 pints of gasoline.

In using the "mineral seal oil" as the absorbent, it was found that the increase in volume of the oil after natural gas had been passed through it did not correspond with the quantity of gasoline subsequently obtained from the oil by distillation. This was due to the fact that a considerable quantity of the lighter hydrocarbons was absorbed from the natural gas and increased the volume of the oil, but escaped as a gas when the oil was subjected to distillation to obtain the absorbed gasoline.

As this loss of material appeared to be considerable, an absorbent was sought that would result in these lighter hydrocarbons being saved. Therefore several tests were made in which natural gas was successively passed through three small absorbers, of the type shown in figure 2; naphtha, having a specific gravity of 55° B., was used in the first and second absorbers and "mineral seal oil" in the third absorber. The object was to absorb most of the gasoline, including the lighter hydrocarbons, with naphtha in the first two absorbers and the rest of the gasoline with "mineral seal oil."

RESULTS OF TESTS.

The results of these tests, which were made on "line L" gas are shown in Table 10 following:

TABLE 10.—*Results of extracting gasoline from natural gas by passing it through naphtha and "mineral seal oil."*

["Line L" gas was used in these tests. The gas was passed through three absorbers in series, the first and second containing naphtha and the third "mineral seal oil."]

Item.	Test 1.			Test 2.			Test 3.		
Absorber	First.	Second.	Third.	First.	Second.	Third.	First.	Second.	Third.
Absorbent used	Naphtha.	Naphtha.	"Mineral seal oil."	Naphtha.	Naphtha.	"Mineral seal oil."	Naphtha.	Naphtha.	"Mineral seal oil."
Specific gravity of absorbent, ° B	53.5	53.5	32.5	55.5	55.5	34.2	55.5	55.5	33.9
Pressure on gas, pounds per square inch	235	235	235	230	230	230	235	235	235
Rate of gas flow, cubic feet per hour	50	50	50	55	55	35.3	180	180	180
Gas used, cubic feet	200	200	200	105	105	105	200	200	200
Oil used, c. c	1,750	1,500	1,500	1,750	1,500	1,500	1,750	1,500	1,500
Oil recovered, c. c	1,950	1,640	1,565	1,925	1,560	1,510	1,850	1,555	1,600
Specific gravity of liquid recovered, ° B	61.6	60.0	37.7	59.6	58.0	36.3	58.2	57.8	36.2
Temperature of liquid in absorber, ° F	27	29	26	19	19	19	54	54	60
Increase in liquid in absorber, c. c	200	140	65	175	60	10	100	55	100
Quantity of sample taken for distillation, c. c	.....	.....	500	.....	.....	503	.....	.....	533
Amount of gasoline distilled from sample, c. c	.....	.....	7	.....	.....	2	.....	.....	26
Yield of gasoline, pints per 1,000 cubic feet of gas	2.114	1.480	.23	3.53	1.21	.12	1.06	.58	.77
Total yield, pints per 1,000 cubic feet of gas	3.82			4.86			2.41		

Item.	Test 4.			Test 5.			Test 6.		
Absorber	First.	Second.	Third.	First.	Second.	Third.	First.	Second.	Third.
Absorbent used	Naphtha.	Naphtha.	"Mineral seal oil."	Naphtha.	Naphtha.	"Mineral seal oil."	Naphtha.	Naphtha.	"Mineral seal oil."
Specific gravity of absorbent, ° B	55.5	55.5	34.2	55.5	55.5	34.2	55.0	55.0	34.2
Pressure on gas, pounds per square inch	235	235	235	235	235	235	235	235	235
Rate of gas flow, cubic feet per hour	54	54	54	180	180	180	56	56	56
Gas used, cubic feet	217	217	217	100	100	100	202	202	202
Oil used, c. c	1,750	1,500	1,500	1,750	1,500	1,500	1,750	1,500	1,500
Oil recovered, c. c	2,040	1,600	1,560	1,810	1,525	1,560	2,020	1,595	1,530
Specific gravity of liquid recovered, ° B	62.0	58.6	36.1	57.3	56.8	35.9	60.9	58.9	36.1
Temperature of liquid in absorber, ° F	28	28	26	60	60	66	18	18	18
Increase in liquid in absorber, c. c	290	100	60	60	25	60	270	95	30
Quantity of sample taken for distillation, c. c	.....	.....	520	.....	.....	520	.....	.....	500
Amount of gasoline distilled from sample, c. c	.....	.....	7	.....	.....	16	.....	.....	5.6
Yield of gasoline, pints per 1,000 cubic feet of gas	2.83	.97	.21	1.27	.53	1.01	2.83	.99	.17
Total yield, pints per 1,000 cubic feet of gas	4.01			2.81			3.99		

COMMENTS ON TESTS.

It will be observed that the gasoline extracted from the natural gas that was passed through naphtha amounted to 4.86 gallons per 1,000 cubic feet of gas in the case of one test. The lowest yield was 2.41 gallons. The increase in yield over the oil absorption and distillation method varied between 300 and 500 per cent.

In test 1 the specific gravity of the naphtha was raised from 53.5° to 61.6° B. in the first absorber and to 60° B. in the second absorber. The increase in volume of the naphtha in the first absorber was 200 c. c., or 11.5 per cent, and in the second absorber, 140 c. c., or about 9.3 per cent.

The greatest increase in volume and specific gravity of the naphtha was obtained in the first absorber in test 4. The specific gravity of the naphtha was raised from 55.5° to 62° B. and the increase in volume was 290 c. c., or about 16.6 per cent. The temperature of the naphtha was 28° F.

The vapor pressure of the naphtha product in the first absorber, test 4, was 5 pounds per square inch at 100° F., and the evaporation or weathering loss was 5 per cent in 24 hours. During this weathering test the temperature of the gasoline rose from 54° to 64° F.; the temperature of the room changed from 56° to 64° F. The temperature of the naphtha had much effect on the results of the tests. The highest yield was that shown in test 2, in which the temperature of the naphtha was 19° F. This test was conducted in the open air on a cold winter day. However, even at a temperature of 60° F. as much as 3.07 pints of gasoline per 1,000 cubic feet of gas was obtained. Test 6 is instructive in that the vapor pressure of the resulting naphtha in the first and second absorbers was 14 pounds per square inch at 100° F., which exceeded that prescribed for gasoline to be shipped in tank cars.

In summing up the results of these tests, as regards the use of naphtha as an absorbent for extracting gasoline from natural gas, it may be stated that a greater yield can be obtained than by using the oil absorption and distillation process, as much as 300 per cent greater at ordinary temperatures and 400 to 500 per cent greater if temperatures as low as 18° to 19° F. are employed. A further advantage lies in the fact that the resulting naphtha with its absorbed gasoline does not have to be subjected to distillation to obtain the gasoline but can be sold as prepared.

An objection to the use of naphtha as an absorbent is that an excessively large amount of naphtha would have to be handled in large-scale operations. In using "mineral seal oil" the same oil can be used over and over again with but slight loss, whereas the naphtha is not used again and would have to be constantly renewed.

As previously stated, the greatest increase in volume of the naphtha was 16.6 per cent, in test 4. This mixture contained about six to seven times as much naphtha as gasoline, so that for each tank of gasoline extracted from the natural gas there would be needed six or seven tanks of naphtha. The naphtha should not be permitted to absorb too much gasoline, as the vapor pressure of the resulting mixture would exceed the limit (10 pounds per square inch at 100° F.) set for the transportation of gasoline in tank cars.

If an absorption gasoline plant could be located at or close to a refinery where a large supply of naphtha was available, the difficulty and trouble of transporting large quantities of naphtha into the absorption plant would be largely overcome, but in most and perhaps all cases this is not feasible.

The problem may be considered as follows: By the oil-absorption process there is obtained one-third as much gasoline as by the naphtha process. If one tank car (10,000 gallons) of this gasoline sells for, say, about 20 cents per gallon, or $2,000, three tanks will sell for $6,000, or an increase of $4,000. But in order to obtain this increase of $4,000 about seven tanks of naphtha would have to be brought to the absorption plant—that is, seven times as much naphtha would have to be handled as the gasoline extracted.

The authors have learned recently of an apparently successful use of naphtha as an absorbent for gasoline in waste gases from a compression plant treating casing-head gas. It so happens that the owner of the compression plant also has interests in a near-by refinery, so that the requisite amount of naphtha can readily be obtained. The naphtha is placed in an absorber and the waste gas from the compression plant passed through it. The naphtha is increased in volume and a salable product is obtained, so that the practice is justified. Practically the same gases are dissolved in the naphtha as accounted for the increased yield when the authors used naphtha in their tests; namely, hydrocarbon gases of lighter weight than true gasoline vapors.

SUMMARY.

The absorption method of extracting gasoline from natural gas consists in bringing the gas in contact with an oil heavier than gasoline, such as a petroleum distillate of about 34° B., to absorb the gasoline from it, and then separating the gasoline from the oil by distillation. The oil is used simply as a carrier of the gasoline from the absorption tank to the still, and may be used over and over again.

In plants using compression and condensation methods only casing-head natural gas that is comparatively rich in gasoline vapor—carrying upward of three-fourths of a gallon of gasoline per 1,000 cubic feet of gas—is treated, whereas so-called "dry" natural gas, such as

A promising field for the absorption process lies in the treatment of gas from oil wells producing from a sand into which air has been forced under pressure to increase the oil production. This gas, as it flows from the wells, can be treated by the absorption process and the gasoline it contains extracted.

The amount of power required for the operation of an absorption plant will vary from 0.018 to 1.443 boiler horsepower per 1,000 cubic feet of gas treated per hour for gas containing 0.0625 to 5 gallons of gasoline per 1,000 cubic feet, and the amount of water from 1.46 to 116.8 gallons per 1,000 cubic feet of gas.

The rate of flow of the absorbing oil will vary from about 6 to 60 gallons per 1,000 feet of gas treated per 24 hours, for gas that contains from 1 pint to 2.5 gallons of gasoline per 1,000 cubic feet.

A successful use of naphtha as an absorbent for gasoline lies in the absorption in the naphtha of waste gases from compression plants treating casing-head gasoline.

Some tests were made in which natural gas was simply passed into naphtha with a gravity of about 55° B. When the naphtha had absorbed all the gasoline that was desired it was removed and fresh naphtha substituted. The yield of gasoline was 300 to 500 per cent greater than that by the oil absorption and distillation process. In some tests the naphtha besides being increased in volume owing to the absorbed gasoline, was raised in specific gravity to 60° or 62° B. An objection to the process lies in the fact that a large amount of naphtha has to be handled—at least seven tanks of naphtha for each tank of gasoline obtained. If the naphtha is permitted to absorb too much gasoline its vapor pressure is raised too high for safe transportation.

There are possibilities in the application of the absorption method to casing-head natural gas, much of which is too lean to be treated by compression and condensation methods.

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